US Army Corps of Engineers®
Portland District

Salmon Recovery through John Day Reservoir

John Day Drawdown Phase I Study

Engineering Technical Appendix Tributary Sedimentation Evaluation Section

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JOHN DAY DRAWDOWN STUDY

TRIBUTARY SEDIMENTATION EVALUATION

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1. INTRODUCTION

1.1 General

In 1991, Snake River wild sockeye, spring, summer, and fall chinook salmon were proposed for endangered or threatened status under provisions of the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS). In its Biological Opinion (BiOp) on operation of the Federal Columbia River Power System, Reasonable and Prudent Action (RPA) #5, NMFS recommended that the Corps of Engineers investigate the feasibility of lowering the John Day reservoir to spillway crest.

Natural resource agencies believe that lowering the John Day reservoir may decrease juvenile salmonid travel times and create a more natural shoreline and benthic community structure, similar to the unimpounded reach of the Columbia River. The main stem spawning populations of fall chinook salmon appear to be healthy and productive in that reach. It has been proposed that drawdown of the 76-mile John Day reservoir may provide substantial improvements in migration and rearing conditions for juveniles by increasing river velocity, reducing water temperature and dissolved gas, and restoring spawning habitat. Drawdown of John Day pool may improve spawning conditions for adult fall chinook by restoring spawning habitat and the natural flow regimes needed for successful incubation and emergence.

The regional goals for a drawdown of John Day reservoir, as identified in NMFS' draft Recovery Plan for Snake River salmon, the Tribal Restoration Plan, and the Northwest Power Planning Council's Fish and Wildlife Programs are to: (1) improve migration and rearing conditions for juvenile spring, summer and fall chinook, sockeye, and steelhead, (2) reduce water temperature and total dissolved gas to comply with Clean Water Act criteria and standards, and (3) improve spawning conditions of fall chinook.

In response to direction provided in the Energy and Water Development Appropriation Bill, 1998, the Corps of Engineers is studying the potential drawdown of the John Day reservoir to spillway crest and natural river conditions. Normal full pool elevation is 265 ft above National Geodetic Vertical Datum (NGVD); operation at spillway crest would result in a pool elevation that will vary from about 217 to 230 ft NGVD; and natural river elevation would be about 170 ft NGVD. The Corps' initial analysis is a reconnaissance-level study evaluating biological, social and economic benefits and costs of the two proposed alternatives, that identifies the potential physical impacts of drawdown. If justified, a feasibility-level evaluation of all the benefits, costs and physical impacts associated with a range of reasonable drawdown alternatives will be performed.

1.2 Goals and Objectives

The John Day Dam creates a 76-mile long reservoir. Reservoirs slow the river current and create slack water. This effect slows the downstream juvenile fish migration through the river system. Drawdown of the 76-mile John Day reservoir is expected to provide substantial improvements in migration and rearing conditions. The drawdown is expected to increase flow velocities along the river, reduce water temperature and restore valuable riparian habitat.

This report presents reconnaissance-level tributary sediment evaluation information for two proposed drawdown scenarios. The two drawdown scenarios are: 1) Spillway Freeflow Conditions, where the reservoir is drawn down the elevation of the spillway, and 2) Natural Conditions, where the dam is breached to allow the river to return to pre-John Day Dam conditions.

1.3 Organization of Report

In addition to this introductory section, the study report is comprised of seven additional sections:

Section 2, DATA, summarizes the sources of information relevant to the study. Previous studies identified from the literature relevant to the current work are reviewed.

Section 3, FISH PASSAGE IMPACT EVALUATION, presents an evaluation of the probable locations of barriers to upstream adult fish migration on each of the major tributaries for which data was available.

Section 4, SEDIMENT BUDGET, presents the methods and results of a sediment budget analysis for stream tributaries to the Columbia River reach between McNary Dam and John Day Dam. Major sources and sinks of sediment through the study area are quantified. The rate of sedimentation within backwater areas along the four major tributaries is estimated.

Section 5, REQUIREMENTS FOR CHANNEL MODIFICATION, presents requirements for channel modifications for the purpose of passing fish and maintaining channel stability along the major tributaries.

Section 6, DREDGING REQUIREMENTS, defines dredging requirements associated with the channel modifications along the main tributaries. Both initial and maintenance dredging volumes are estimated.

Section 7, SUMMARY, describes the overall conclusions and recommendations of the investigation of tributary sediment issues associated with the drawdown alternatives for the John Day Pool.

Section 8, REFERENCES, identifies the sources of information utilized in preparing the study.

2. DATA

2.1 Previous Studies

A significant effort was made to identify, collate, and review existing literature for pertinent data and information. A major objective of the literature review was to identify existing data and appropriate methods of analysis. This included review of a 1995 tributary sedimentation evaluation for the John Day Pool conducted by Ogden Beeman & Associates, Inc. and Ayres Associates (Ayres), contacts with Battelle Northwest, Oregon State University, and the U.S. Geological Survey (USGS). The Ogden Beeman study consisted of a field evaluation of the major tributaries to the John Day Pool and provides qualitative evaluations of the impact of reservoir drawdown on each tributary from an erosion and sedimentation perspective. Suspended sediment measurement data were obtained from the USGS for the John Day River, Umatilla River, Willow Creek and Rock Creek.

2.2 Topographic Data

Topographic data from 1935, 1955, and 1994 developed by the Corps of Engineers were collected and evaluated. Preliminary digital terrain models (DTM's) created by Ogden-Beeman Associates (Ogden-Beeman, 1995) were obtained from the Portland District. The DTM's included data from 1955 and 1994 hydrographic surveys conducted by the Corps of Engineers for the John Day River, Umatilla River, and Willow Creek. Survey data was only available for 1994 along Rock Creek. No hydrographic survey data was available for Wood Gulch.

Cross sections were defined from the hydrographic survey DTM's using Eagle Point and AutoCAD software. The profile plots were developed for all the four major tributaries and comparisons of topographic changes between 1955 and 1994 were made for John Day River, Umatilla River, Willow Creek and Rock Creek. This was done in order to provide comparisons and help calculate sedimentation volumes that have occurred since the dam was constructed. Ogden Beeman & Associates previously developed estimates of the volume of sedimentation between 1955 and 1994 for the John Day River, Willow Creek, and Umatilla River. Those estimates were confirmed as part of this study.

2.3 Hydrology

Ogden Beeman and Associates, Inc. studied the hydrology of John Day River, OR; Umatilla River, OR; Willow Creek, OR; and Rock Creek, WA. Their analysis was adopted for use in this section. For each stream, the average annual, average monthly, and annual flow-duration statistics were calculated. In addition, the instantaneous peak flows for different flood events were determined. A summary of average flow statistics is given in Table 2-1. Flow-duration statistics are shown in Table 2-2. Instantaneous peak flow statistics are summarized in Table 2-3 Table 2-4, Table 2-5 and Table 2-6.

Table 2-1: Average annual and monthly discharges for major tributaries (from Ogden Beeman, 1996).

Tributary	Average Discharge (cfs)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
John Day R.	327	614	1185	1642	2562	3989	5669	5182	2709	658	195	185	2073
Umatilla R.	85	241	523	703	946	1185	1329	666	155	30	26	39	492
Willow Cr.	0.7	6.6	41	85	73	50	63	47	10	1.3	1.7	0.7	31
Rock Cr.	5.8	16	50	75	171	219	136	65	19	4.6	2.7	3.1	63

Table 2-2: Annual flow-duration values for major tributaries based on daily flows (from Ogden Beeman, 1996).

Tributary	Discharge (cfs) equaled or exceeded for indicated percent of time														
	90	90	85	80	75	70	60	50	40	30	25	20	15	10	5
John Day R.	85	141	200	263	324	385	532	792	1360	2240	2800	3500	4460	5800	8010
Umatilla R.	2.4	7	11	14	21	36	86	135	236	446	588	770	1020	1390	2160
Willow Cr.	0.0	0.0	0.0	0.1	0.2	0.3	0.8	1.5	3.9	13	23	36	53	80	142
Rock Cr.	0.4	1.1	1.9	1.9	3.7	4.8	8.7	14	26	47	65	90	126	182	294

2.3.1 John Day River, OR

The U.S. Geological Survey gage #14048000 at McDonald's Ferry on the John Day River (River Mile 20.9) was used to characterize the hydrology for the John Day River. In operation since 1906, the gage recorded a peak discharge of 42,800 cfs on December 24, 1964. The basin area above the gage includes approximately 7,580 square miles with no major tributaries entering the John Day River downstream of the gage. The mean annual precipitation for the drainage basin is approximately 19 inches, and around 41.8 percent of the drainage basin is covered by forests. While the river is not regulated, there are many irrigation diversions upstream from the station. Table 2-3 provides the annual peak flow frequency statistics developed by Ogden Beeman (1996) for the John Day River for various recurrence intervals.

Table 2-3: John Day River peak flow frequencies (from Ogden Beeman, 1996).

John Day River Annual Peak Flow Frequency Drainage Area = 7,580 square miles		
Annual Exceedance Probability	Return Interval (Years)	Peak Discharge (cfs)
0.5	2	12,500
0.2	5	19,500
0.1	10	24,500
0.05	20	29,500
0.02	50	36,200
0.01	100	41,400

2.3.2 Willow Creek, OR

The U.S. Geological gage #14036000 at Willow Creek near Arlington, OR, was used to characterize the hydrology for the basin. The gage was located on Willow Creek near River Mile 3.7 with the basin area above the gage approximately 850 square miles. In operation from August 1960 to September 1979, the gage's peak discharge of record was 16,900 cfs on January 14, 1974. Peak flow statistics do not account for regulation by Willow Creek Dam, in operation since 1983, located near Heppner, Oregon. The mean annual precipitation is approximately 14 inches while forested cover represents roughly 6.8 percent of the basin. Peak flow frequency statistics for Willow Creek developed by Ogden Beeman (1996) are provided in Table 2-4.

Table 2-4: Willow Creek peak flow frequencies (from Ogden Beeman, 1996).

Willow Creek Annual Peak Flow Frequency Drainage Area = 850 square miles		
Annual Exceedance Probability	Return Interval (Years)	Peak Discharge (cfs)
0.5	2	1,065
0.2	5	5,070
0.1	10	9,961
0.04	25	18,553
0.02	50	26,360
0.01	100	35,017

2.3.3 Umatilla River, OR

The USGS data records, gage #14033500 on the Umatilla River near Umatilla, OR (RM 2.1) were used to characterize the hydrology of the basin. Since the gage started operation in November 1903, the peak discharge of record is 19,800 cfs on January 30, 1965. The basin area includes approximately 2,290 square miles with a mean annual precipitation of less than 15 inches. Approximately 16 percent of the basin is forested. The river has experienced some regulation by McKay Reservoir since 1927 and has many irrigation diversions upstream of the station. The Cold Springs Reservoir, an off-channel reservoir with a capacity of 52,380 acre-feet, has diverted water since 1908. In addition, Brownell Canal diverts flow just downstream of the gaging station. Peak flow frequency statistics for the Umatilla River developed by Ogden Beeman (1996) are provided in Table 2-5.

Table 2-5: Umatilla River peak flow frequencies (from Ogden Beeman, 1996).

Umatilla River Annual Peak Flow Frequency Drainage Area = 2,290 square miles		
Annual Exceedance Probability	Return Interval (Years)	Peak Discharge (cfs)
0.5	2	5,040
0.2	5	8,160
0.1	10	10,600
0.05	20	13,300
0.02	50	17,200
0.01	100	20,600

2.3.4 Rock Creek, WA

The Ogden Beeman Study (1996) used a gage on a stream in Oregon that had similar hydrologic characteristics to Rock Creek and a longer period of record. The gage used for the analysis was #14047390 located on Rock Creek above Whyte Park near Condon, OR. Although the two creeks have a similar name, they are not the same. The basin area of Rock Creek, WA includes approximately 226 square miles. The measured percent of forested area is 27 percent, and the mean annual precipitation for the basin is 16.9 inches. A qualitative comparison was made with data available for the USGS gage #14036600 located on Rock Creek near Roosevelt, WA for water years 1963 to1968. The period of record for the two gages do not overlap, so a direct comparison could not be made. However, the hydrographs of daily discharge appeared to have similar characteristics.

The gage at Rock Creek, OR has a slightly larger drainage area (297 square miles to 226 square miles), was used by Ogden Beeman (1996) to estimate the hydrology. The monthly, annual, and flow duration statistics from Rock Creek, OR were used to represent the statistics for Rock Creek, WA. Peak flow frequency statistics for the Rock Creek developed by Ogden Beeman (1996) are provided in Table 2-6.

Table 2-6: Rock Creek estimated peak flow frequencies (from Ogden Beeman, 1996).

Rock Creek Annual Peak Flow Frequency Drainage Area = 226 square miles		
Annual Exceedance Probability	Return Interval (Years)	Peak Discharge (cfs)
0.2	5	2,937
0.1	10	4,213
0.04	25	6,770
0.02	50	8,672
0.01	100	11,167

2.4 Hydraulics

The Corps of Engineers River Analysis System standard-step backwater computer program (HEC-RAS Version 2.0) (U.S. Army Corps of Engineers, 1997) was used to compute channel hydraulics for John Day River, Umatilla River, Willow Creek, and Rock Creek. Cross sections were extracted from the digital terrain models (DTM's) using Eagle Point and AutoCAD commercial software. They were then electronically imported into HEC-RAS. The cross section data was then modified to reflect existing conditions.

2.5 Sediment Transport

The sediment transport conditions of the major tributaries and other significant tributaries (>1 square mile) to the John Day pool were investigated. A total of 35 tributaries to the John Day Pool were identified (see Table 2-7). The five largest tributaries (John Day River, Umatilla River, Willow Creek, Glade Creek and Rock Creek) were found to encompass 91.3 percent of the total drainage area for all 35 tributaries. Of these five, only John Day River, Umatilla River, Willow Creek, and Rock Creek are considered for fish passage. Glade Creek is not known to support anadromous fish (Willis, 1999). Although not one of the five largest tributaries, Wood Gulch does support anadromous fisheries and is considered a stream of concern for fish passage.

A field reconnaissance of significant tributary streams was conducted. Observations were made of the conditions of sedimentation and erosion in areas influenced by the backwater of the existing John Day Pool. The influence of man-made and geologic controls on the stability of each tributary was qualitatively evaluated. The potential for significant impacts due to reservoir drawdown was also noted. Findings are summarized in Section 4.

Ogden Beeman and Associates, Inc. collected 26 sediment samples from the four major tributaries of the John Day pool. Plots of grain size analysis, based on the field sampling, were developed (see Attachment A). For the current study, the SAM model (USACE, 1998) was used to calculate the sediment transport capacity of John Day River, Umatilla River, Willow Creek and Rock Creek, using the information obtained from the HEC-RAS hydraulic model and flow-duration curves developed by Ogden Beeman & Associates (1996).

Daily values of suspended sediment transport for four of the major tributaries to the John Day Pool were obtained from the USGS. These data were for the period 1963 to 1970 for the John Day River at McDonald Ferry, OR and Umatilla River near Umatilla, OR; 1963 to 1968 for Rock Creek near Roosevelt, WA; and 1968 to 1970 for Willow Creek near Arlington, OR. These data were plotted against daily discharge on a log-log scale graph to create a suspended sediment rating curve (see Attachment B).

Table 2-7: Tributary ranking based on drainage area

Rank	TRIBUTARY	DRAINAGE AREA (square miles)	% OF TOTAL
1	JOHN DAY RIVER	7872	63.23
2	UMATILLA RIVER	2292	18.41
3	WILLOW CREEK	855	6.87
4	GLADE CREEK	347	2.79
5	ROCK CREEK	226	1.82
6	ALDER CREEK	197	1.58
7	SIXMILE CANYON	144	1.16
8	FOURMILE CANYON	91.4	0.73
9	DEAD CANYON	76.9	0.62
10	WOOD GULCH	63.8	0.51
11	PINE CREEK	58.7	0.47
12	CHINA CREEK	49.84	0.40
13	NO NAME 11	42.6	0.34
14	CHAPMAN CREEK	24.1	0.19
15	OLD LADY CANYON	19.2	0.15
16	BLALOCK CANYON	16.85	0.14
17	JONES CANYON	14.85	0.12
18	HELM CANYON	8.58	0.07
19	THREEMILE CANYON	7.15	0.06
20	LANG CANYON	6.52	0.05
21	NO NAME 1	5.1	0.04
22	MYERS CANYON	4.84	0.04
23	SAND SPRING CANYON	4.83	0.04
24	PHILLIPI CANYON	4.76	0.04
25	JU CANYON	2.78	0.02
26	SWANSON CREEK	2.45	0.02
27	NO NAME 6	1.68	0.01
28	NO NAME 10	1.59	0.01
29	NO NAME 8	1.51	0.01
30	NO NAME 7	1.17	0.01
31	NO NAME 5	1.16	0.01
32	NO NAME 2	1	0.01
33	NO NAME 3	0.93	0.01
34	NO NAME 4	0.81	0.01
35	NO NAME 9	0.77	0.01

3. FISH PASSAGE IMPACT EVALUATION

Sedimentation in the major tributaries of the John Day Pool that has occurred since the completion of the John Day Dam may impact fish passage under the proposed drawdown scenarios. Changes to the channel geometry will impact channel hydraulics causing a potential blockage to adult fish migration. Potential blockages to fish migration could be caused by either large flow velocities and/or shallow depths. Hydraulic models for John Day River, Umatilla River, Willow Creek, and Rock Creek were developed based on exiting (1994) geometry. No data was available for Wood Gulch so a hydraulic model was not developed. The flow depths and velocities were compared to passage criteria, developed for the fish species of concern, to determine potential passage concerns. It is recognized that under the proposed drawdown conditions, the changes in channel hydraulics will change the sediment transport characteristics of the channel potentially altering the channel geometry. This could cause existing blockages to be removed and/or create new blockages.

3.1 Species of Concern

Fish species known to be present in the tributaries to the John Day pool include: Fall; Spring and Summer Chinook Salmon; Coho Salmon; Sockeye Salmon; and Summer, Winter and Spring Steelhead. Adult migration of these species typically occurs according to the schedule shown in Figure 3-1. The periods of migration were used to determine the timing and magnitude of flows in the tributaries for analysis of fish passage.

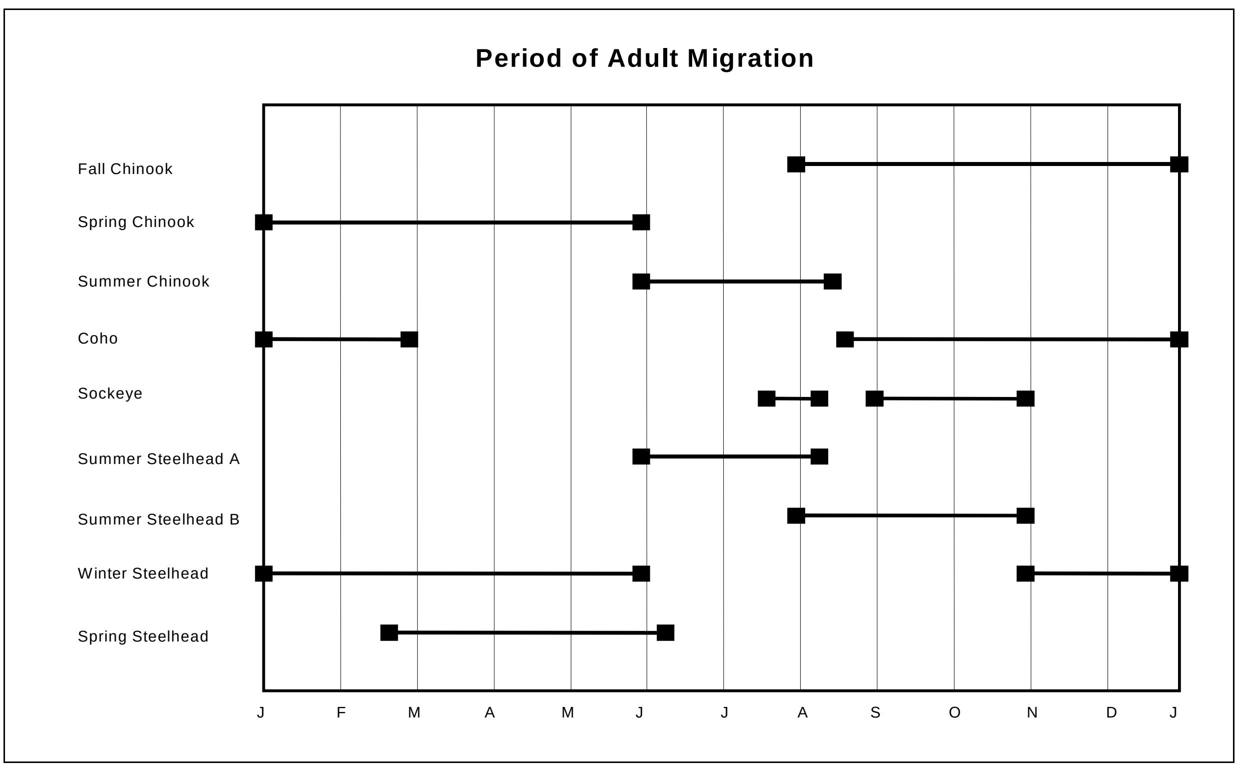


Figure 3-1: Period of adult salmonid migration in the vicinity of the John Day dam (based on USACE, 1990).

3.2 Fish Passage Requirements

The ability of the fish species of concern to migrate upstream may be adversely influenced by the existence of barriers to their passage. These barriers may include such things as dams, waterfalls, insufficient water depths, or high flow velocities that cannot be overcome. Fish passage requirements evaluated include both velocity and depth criteria. Flow velocity was evaluated based on consideration of three criteria for swimming speeds. These criteria include: 1) cruising speed – a speed that can be maintained for long periods of time (hours); 2) sustained speed – a speed that can be maintained for minutes; and 3) darting speed – a single effort that is not sustainable. Fish normally employ cruising speed for movement (as in migration), sustained speed for passage through difficult areas and darting speed for feeding or escape purposes (USACE, 1990). Cruising, sustained and darting speeds for the species of concern are shown in Table 3-1.

Table 3-1: Swimming speed criteria for adult salmonid migration (from USACE, 1990).

Species	Swimming Speed		
	Cruising Speed (ft/s)	Sustained Speed (ft/s)	Darting Speed (ft/s)
Fall Chinook	4.00	11.00	21.50
Spring Chinook	4.00	11.00	21.50
Summer Chinook	4.00	11.00	21.50
Coho	4.00	11.00	21.00
Sockeye	4.00	11.00	21.00
Summer Steelhead A	5.00	15.00	27.00
Summer Steelhead B	5.00	15.00	27.00
Winter Steelhead	5.00	15.00	27.00
Spring Steelhead	5.00	15.00	27.00

Specific depth criteria for adult migration is not well documented. In order to determine the locations of concern for fish passage that involved shallow depths, a minimum depth criterion of one foot was used as an indicator of potential blockages to upstream migration.

3.3 Hydraulic Analysis

Site-specific hydraulic characteristics along the four major tributaries were evaluated using the Corps of Engineers HEC-RAS, Version 2.2 (USACE, 1997), standard-step backwater computer program. The input cross sectional data for the HEC-RAS program were obtained from the 1994 survey data. The five tributaries to the John Day pool known to have salmonids in them include John Day River, Willow Creek, and Umatilla River on the Oregon side and Rock Creek and Wood Gulch on the Washington side. Glade Creek, a major tributary to the John Day Pool, is not considered to have fish habitat (Willis, 1999). All tributaries except Wood Gulch were modeled using HEC-RAS. No hydrographic or topographic data were available for Wood Gulch.

Tributary flows used in the hydraulic analysis were determined by identifying the lowest and highest average monthly discharges during the period of adult migration for the species of concern. This was done to capture the range of velocities and depths to be expected during adult fish migration. Stage-discharge rating curves corresponding to each of the proposed conditions were developed for the Columbia River at the mouth of each tributary. This was done to determine the starting water surface elevation for each discharge used in each of the tributary hydraulic models. Average monthly flows in the Columbia River were chosen based on the same month used for the tributary. For example, the highest monthly flow occurring during adult migration on the John Day River was 2,562 cfs in February, while the flow chosen for the Columbia River was 179,465 cfs, also occurring in February. Based on the rating curves developed for the Columbia River at the mouth of the John Day, the starting water surface elevations would be 225.01 ft and 163.61 ft for spillway freeflow and natural drawdown conditions, respectively. The flows and starting downstream water surface elevations used in the tributary hydraulic (HEC-RAS) models are shown in Table 3-2.

Table 3-2: Critical fish flows and downstream water surface elevations modeled in HEC-RAS

Tributary	**Discharge (cfs)**	**Existing**	**Spillway Freeflow**	**Natural**
		W.S. Elev (ft)	**W.S. Elev (ft)**	**W.S. Elev (ft)**
John Day River	185	265.00	221.07	161.65
Rock Creek	3	265.00	222.08	172.04
Willow Creek	1	265.00	221.03	200.83
Umatilla River	26	265.00	252.38	252.40
John Day River	2,562	265.00	225.01	163.61
Rock Creek	65	265.00	230.22	178.82
Willow Creek	10	265.00	229.99	208.30
Umatilla River	666	265.00	257.81	257.83

3.4 Fish Passage Barrier Analysis

For the four main tributaries with hydraulic models, river velocities and depth were evaluated for potential barriers to adult fish passage. In order to determine whether the velocity of the river is too high to allow fish passage, the duration or amount of time a particular fish species can maintain a particular velocity was determined. Table 3-3 summarizes the duration for swimming speeds for each adult fish species.

Table 3-3: Duration of velocities for adult fish species of concern.

Species	*Duration		
	Cruising Speed Duration (s)	Sustained Speed Duration (s)	Darting Speed Duration (s)
Fall Chinook	Indefinite	56.00	7.50
Spring Chinook	Indefinite	56.00	7.50
Summer Chinook	Indefinite	56.00	7.50
Coho	Indefinite	52.18	7.50
Sockeye	Indefinite	52.18	7.50
Summer Steelhead A	Indefinite	43.74	7.50
Summer Steelhead B	Indefinite	43.74	7.50
Winter Steelhead	Indefinite	43.74	7.50
Spring Steelhead	Indefinite	43.74	7.50

* Based on the formula from the Fisheries Handbook of Engineering and Biological Criteria (USACE, 1990).

For each cross section in the tributary hydraulic models, average velocity and maximum depth were computed. These values were assumed to apply for the stream segment defined as half the distance between successive cross sections. This was done to determine the distance over which the river velocities would apply. At any cross section where the average channel velocity equaled or exceeded the cruising velocity (four feet per second for Chinook, Coho, and Sockeye or five feet per second for Steelhead), this location was considered a possible barrier to fish.

The net upstream velocity of the fish was calculated as the difference between the downstream channel velocity and the upstream-sustained velocity. The distance to the next upstream stream segment with velocity less than the cruising speed was then divided by net upstream velocity of the fish to determine the travel time necessary to pass the section of high velocity. If the upstream travel time exceeded the duration values given in Table 3-3, then this location was again considered a potential barrier to fish. As a final check, the same procedure was used with the darting velocity. Where the upstream travel time exceeded 7.5 seconds, it was determined that a potential blockage to fish passage exists. In addition to velocity criteria, each cross section was evaluated for maximum depths for the flows modeled. Any cross section having a maximum depth of less than one foot was considered a potential barrier to adult fish passage.

The John Day River was the only stream modeled with potential barriers based on velocity criteria. Potential velocity barriers were found for the natural conditions drawdown scenario. Willow Creek, Umatilla River, and Rock Creek have potential barriers due to failure of the one foot minimum depth criteria. Results of the fish passage barrier analysis are shown in Table 3-4 and Table 3-5 for spillway freeflow and natural drawdown conditions, respectively.

Table 3-4: Summary of fish passage analysis (spillway freeflow conditions).

John Day River		Max Q = 2562 cfs		Min Q = 185 cfs						
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Max Q	Sustained									
	Darting									
	Cruising									
Min Q	Sustained									
	Darting									
Depth Criteria										
Max Q	>1 foot	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	>1 foot	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Willow Creek		Max Q = 47 cfs		Min Q = 1 cfs						
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Max Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Umatilla River		Max Q = 666 cfs		Min Q = 26 cfs						
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Max Q	Sustained	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
	Darting	-	-	-	-	-	-	-	-	-
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Table 3-4 (continued):

Rock Creek		Max Q = 65 cfs		Min Q = 3 cfs						
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Max Q	Sustained	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
	Darting	-	-	-	-	-	-	-	-	-
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

KEY
Fail = No Passage based on velocity or depth criteria
Pass = Passage based on velocity or depth criteria
- = No additional analysis required

Table 3-5: Summary of fish passage analysis (natural conditions).

John Day River		Max Q = 2562 cfs		Min Q = 185 cfs						
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Max Q	Sustained	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
	Darting	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
	Cruising	Fail	Fail	Fail	Fail	Fail	Pass	Pass	Pass	Pass
Min Q	Sustained	Fail	Fail	Fail	Fail	Fail	-	-	-	-
	Darting	Fail	Fail	Fail	Fail	Fail	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Willow Creek		Max Q = 47 cfs		Min Q = 1 cfs						
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Max Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Umatilla River		Max Q =	666 cfs	Min Q =	26 cfs					
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Max Q	Sustained	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
	Darting	-	-	-	-	-	-	-	-	-
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

Table 3-5 (continued):

Rock Creek		Max Q =	65 cfs	Min Q =	3 cfs					
Velocity Criteria		Fall Chinook	Spring Chinook	Summer Chinook	Coho	Sockeye	Summer Steelhead A	Summer Steelhead B	Winter Steelhead	Spring Steelhead
	Cruising	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
Max Q	Sustained	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
	Darting	-	-	-	-	-	-	-	-	-
	Cruising	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	Sustained	-	-	-	-	-	-	-	-	-
	Darting	-	-	-	-	-	-	-	-	-
Depth Criteria										
Max Q	>1 foot	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Min Q	>1 foot	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail

KEY
Fail = No Passage based on velocity or depth criteria
Pass = Passage based on velocity or depth criteria
- = No additional analysis required

4. SEDIMENT BUDGET

An evaluation of sediment transport characteristics of the tributaries to the John Day Pool was made to understand how they would be impacted by the proposed drawdown conditions and to help determine what implications these tributaries might have on such things as navigation in the main John Day Pool. An analysis of the sediment transport characteristics for the four major tributaries was conducted to understand impacts of sedimentation on fish passage and the implications for maintaining fish passage.

4.1 Qualitative Evaluation

A qualitative evaluation of sediment inputs from tributaries to the John Day Pool was conducted. A field inspection of the 31 minor tributaries revealed the relative contribution of sediment that is expected from these basins. In addition, an evaluation of the pre-dam (1955) topographic maps revealed the relative impact of tributary sediment inputs to the confluence with the river prior to the formation of the pool.

Of the 31 minor tributaries, only 20 showed evidence of sediment contribution to the river prior to the formation of the pool. Current field conditions indicate that the majority of these tributaries, with such hydraulic structures as culverts, block the majority of the sediment from entering the pool. Current contributors of sediment to the John Day Pool are typically those streams with bridges at their confluence. These include Glade Creek, Alder Creek, Dead Canyon, Wood Gulch and Chapman Creek. Of these, Glade Creek appears to be the largest contributor. Some of the smaller tributaries with culverts, including Sand Spring Canyon and Ju Canyon, appear to contribute relatively minor amounts of sediment to the John Day Pool. A summary of the findings is shown in Table 4-3.

4.2 Quantitative Evaluation

Suspended sediment data and changes in channel topography were used to estimate the amount of sediment that is contributed by the four major tributaries to the John Day pool. Values from these tributaries were used to estimate sediment inputs from the smaller nearby tributaries that were deemed significant in the qualitative evaluation.

4.2.1 Average Annual Sediment Load

Daily values of suspended sediment transport for the major tributaries to the John Day Pool were obtained from the USGS. The data was for periods 1963 to 1970 for both the John Day and Umatilla Rivers, 1963 to 1968 for Rock Creek, and 1968 to 1970 for Willow Creek. This sediment data were plotted against mean daily discharge on a log-log scale graph to create a sediment rating curve (see Attachment B). The rating curve was then input into the SAM computer package (USACE, 1998) and integrated with the available flow duration information to estimate the average annual sediment load for each stream. It is recognized that the suspended sediment data used in the analysis is for a rather short period of record and may not represent the full range of hydrologic and sediment transport conditions that could occur along each stream.

A comparison of DTM's for 1955 and 1994 hydrographic surveys was conducted to measure the amount of sediment accumulation. The accumulated volume was divided by the number of years of accumulation to determine the accumulation rate for average annual sediment volume. The average annual accumulation is considered to represent the average annual bed material load contribution for each stream. The wash load represents the finest particles (fine silts and clays) of the suspended sediment load and is assumed to move through the system and not deposit within the tributary. Table 4-1 summarizes average annual sediment loads determined for the major tributaries.

Table 4-1: Average annual tributary sediment loads.

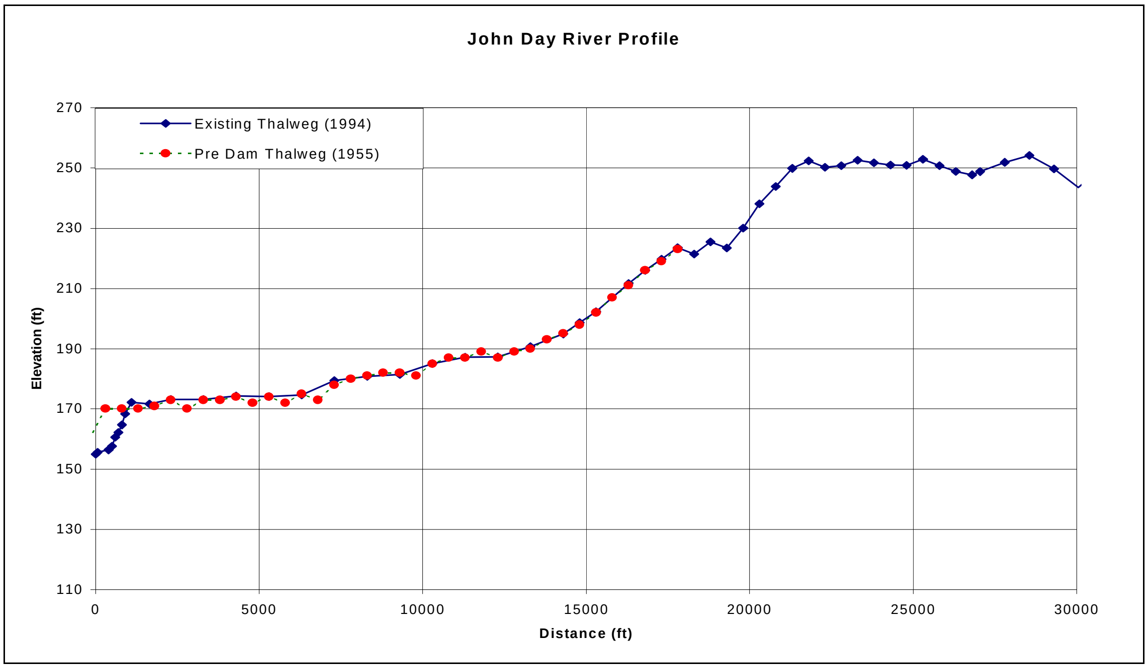
Tributary	Average Annual Suspended Sediment Load Rating Curve (tons/year)	*Measured Average Annual Accumulation 1955 and 1994 Surveys (tons/year)	*Measured Average Annual Accumulation 1955 and 1994 Surveys (% of Suspended Load)
John Day River	720,444	76,729	11%
Willow Creek	748,745	132,363	18%
Umatilla River	608,291	6,670	1.1%
Rock Creek	28,004	**23,872	85%

*Measured accumulation assumes a sediment density of 93 lb/cu.ft.
**No DTM available for 1955. Estimated using the thalweg elevation from the 1955 topographic map, assuming triangular cross sections and top widths measured from the 1994 topographic map.

4.2.1.1 John Day River

The John Day River is controlled by bed rock at approximately river mile 4.5. At this location the slope changes from approximately 1.6 feet per mile upstream to 20 feet per mile downstream. The accumulated bed material accounts for roughly 11 percent of the suspended load. Suspended sediment size distributions showed that sediment finer than 0.0625 (silt) typically comprised 85 to 95 percent of the sample (USGS, 1999). Although sedimentation has occurred within the lower portion of the John Day River, the thalweg profile comparison shown in 4-1 shows that very little change has occurred between pre-dam (1955) and post-dam (1994). More significant sedimentation may have occurred further upstream where data is unavailable.

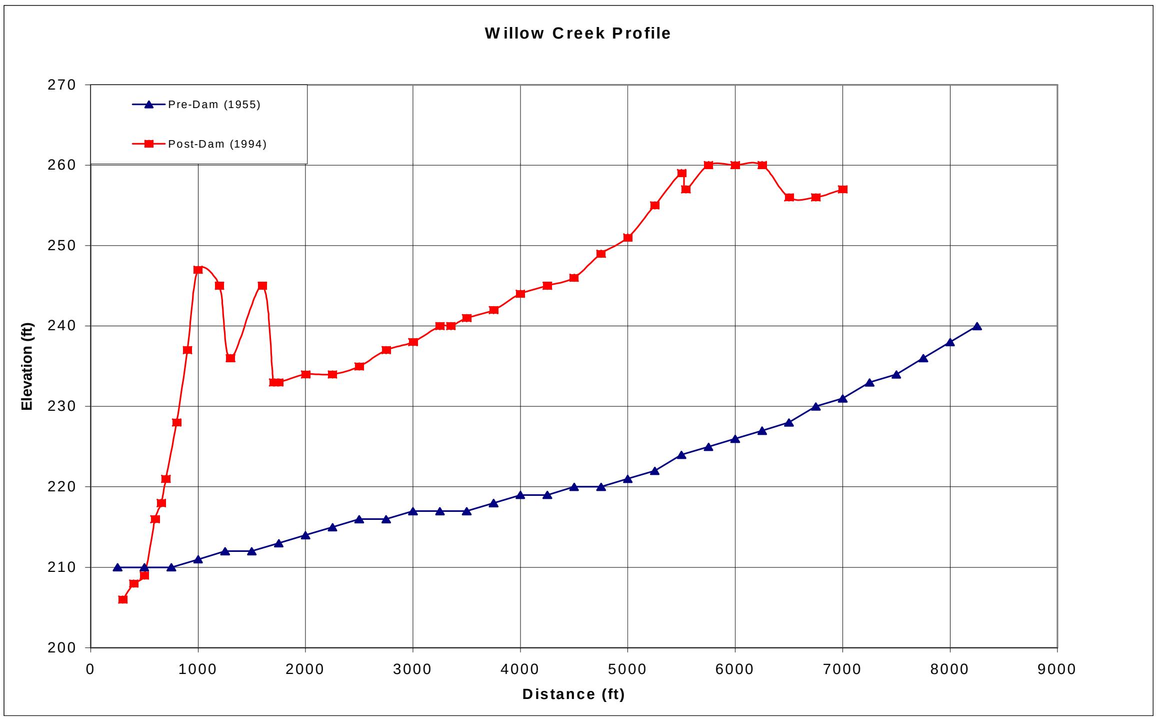
Figure 4-1: Pre- and post-dam thalweg profiles for John Day River.



4.2.1.2 Willow Creek

The mouth of Willow Creek is constricted by the I-84 freeway bridges as well as a railroad bridge. Backwater from the Columbia extends several miles upstream and thus severely reduces the capacity of the river to transport sediment. Because of this, a large quantity of sediment has deposited at and above the mouth of Willow Creek. The thalweg profiles shown in Figure 4-2 suggest between 20 and 40 ft of aggradation has occurred since the creation of the John Day Pool. The largest changes shown are at the location of the I-84 freeway bridge and railroad bridge. These however, may be anomalous and not represent the actual thalweg of the river.

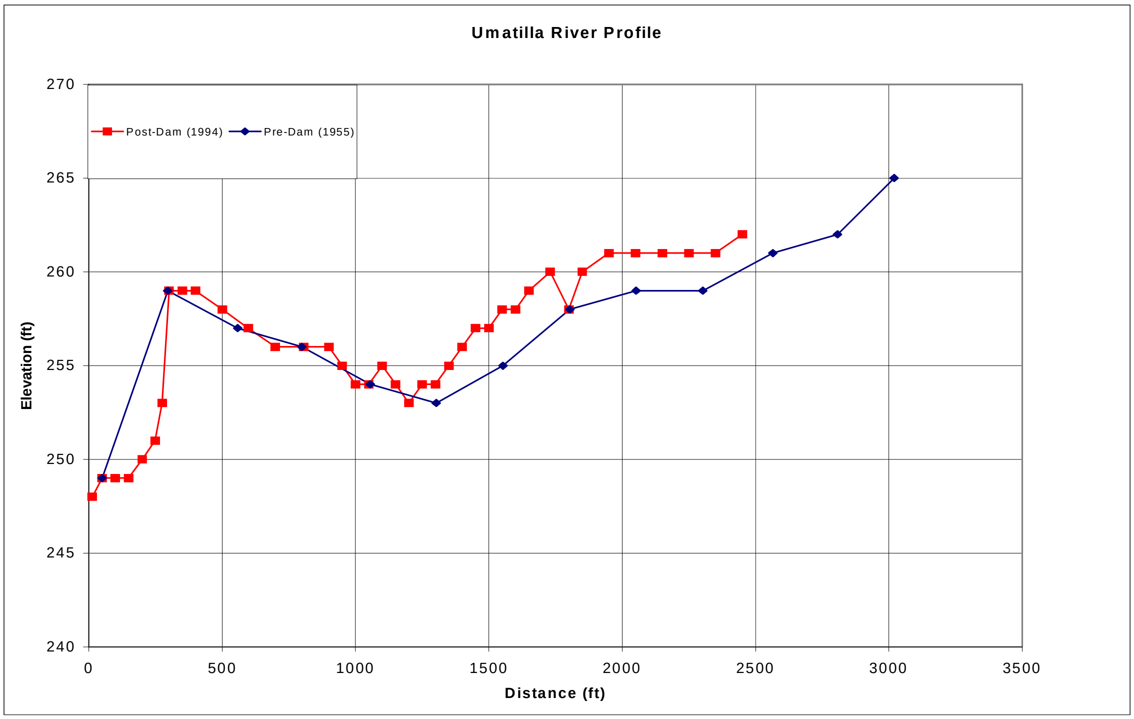
Figure 4-2: Pre- and post-dam thalweg profiles for Willow Creek



4.2.1.3 Umatilla River

The Umatilla River basin has several irrigation reservoirs developed within it. These have been in place since the late 1920's. Since the majority of the bed material load is usually trapped by reservoirs (ASCE, 1977), it is expected that the Umatilla River would have little accumulation compared to the average annual suspended sediment load. The majority of the sediment deposited in the backwater portion of the Umatilla River is likely the very fine-grained sands, silts and clays (wash load) that are transported through the reservoirs and any locally derived material from bellow the dams. The thalweg profiles shown in Figure 4-3 shows only a minor accumulation of sediment in the upstream portion of the study reach.

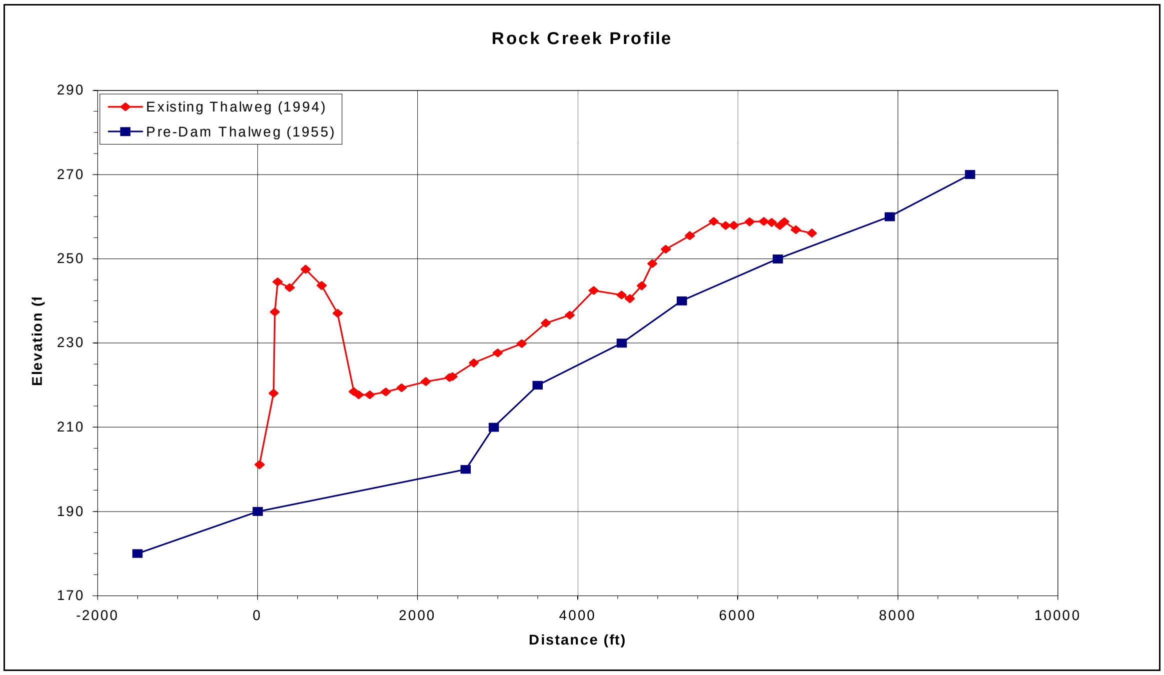
Figure 4-3: Pre- and post-dam thalweg profiles for Umatilla River.



4.2.1.4 Rock Creek

Rock Creek is a gravel and cobble bed stream. Because of the armoring characteristics of gravel bed streams, significant quantities of suspended sediment are typically only transported during events that transport bed material. Additionally, the outlet of Rock Creek acts like a dam, creating a reservoir that is more efficient at trapping sediment than a natural river outlet. These two conditions may account for the larger percentage of suspended load deposited in the channel compared to the other tributaries. Deposition in the channel represents approximately 85 percent of the suspended load. Pre- and post-dam thalweg profiles are shown in Figure 4-4. The pre-dam (1955) thalweg data was taken from topographic maps. No digitized hydrography data was available for pre-dam conditions. The largest change in the profile near the downstream end of the plot is due to the relocated outlet of Rock Creek. The pre-dam outlet to Rock Creek was filled in and a new outlet, located to the east, was cut through bedrock. The highest points located at approximately station 500 in Figure 4-4 represent this notch.

Figure 4-4: Pre- and post-dam thalweg profiles for Rock Creek.



4.2.2 Sediment Transport Capacity

The computer package SAM (USACE, 1998) was used to estimate the capacity of the tributaries to transport sediment under both spillway freeflow and natural drawdown conditions. The Toffaleti – MPM method in SAM, as suggested by the Corps of Engineers (USACE, 1995), was used to develop a transport capacity rating curve for each tributary considered. The rating curve was integrated with the available flow-duration information for each tributary to estimate the average annual sediment transport capacity for each tributary. Although sediment transport equations often do not accurately represent the true conditions of the river, they are used here for comparative purposes. The computed values represent the relative magnitude of changes in sediment transport characteristics expected under the different drawdown scenarios. Table 4-2 summarizes the results of the analysis. It is also recognized that the results are only for one cross section on each tributary, and are not expected to represent the entire study reach.

Table 4-2: Tributary average annual sediment transport capacity.

Average Annual Sediment Transport Capacity			
Tributary	Existing Conditions (tons/year)	Spillway Freeflow (tons/year)	Natural (tons/year)
John Day River	3,385	289,471	547,681
Willow Creek	12	165,700	326,066
Umatilla River	2,016	29,957	30,948
Rock Creek	19	6,000	6,262

The sediment transport capacity estimates were made using one of the upstream most cross sections and bed material samples for each tributary. This was done to define transport conditions based on a transport reach rather than a depositional reach. As can be seen from Table 4-2 the transport capacity of the tributaries is affected by backwater. In all cases, the transport capacity of the tributary is highest under natural conditions. It is recognized however, that the estimates are for one cross section and existing geometry. The transport capacity of the stream will vary by location and the channel geometry will change as the river adapts to its new boundary conditions.

4.2.2.1 John Day River

Backwater from the Columbia extends approximately 10 miles upstream of the John Day River mouth. This reduces the capacity of the river to transport coarse sediments. Under spillway freeflow and natural conditions, the transport capacity is in excess of the measured accumulation rate.

4.2.2.2 Willow Creek

Under spillway freeflow and natural conditions, the estimated transport capacity of Willow Creek is in excess of the measured accumulation rate. This should allow the channel to pass the majority of its inflowing sediment to the Columbia River. Willow Creek Dam, located upstream and completed in 1983, may act to further reduce the sediment supply to Willow Creek. Recent observations of the channel incision upstream of the John Day Pool backwater, suggests a reduced supply of sediment to this reach. The reduction of sediment supply will provide excess sediment transport capacity. Additional sediment will be propagated from the bed and banks to make up for the reduced supply. Subsequent erosion of the bed and banks is expected causing alteration of the channel’s existing geometry.

4.2.2.3 Umatilla River

At the mouth of the Umatilla River, located at the upper end of the pool, the Columbia River backwater is nearly the same for both drawdown conditions considered. Thus, sediment transport capacity of the Umatilla River is nearly the same for both alternatives. It is also recognized that there exist several irrigation reservoirs within the Umatilla River basin, that have likely reduced the amount of bed material available for transport.

4.2.2.4 Rock Creek

The outlet of Rock Creek is cut through rock, which acts like a weir during both spillway freeflow and natural conditions. The weir acts to control the backwater and thus the sediment transport capacity in Rock Creek. Unless the outlet is reconfigured, Rock Creek will continue to trap sediment.

4.2.3 Minor Tributaries

Sediment contributions to the John Day pool by the 31 minor tributaries were estimated using the results of the four main tributaries and the qualitative evaluation (Table 4-3). The average annual suspended sediment load for the four main tributaries is approximately 340 tons per square mile. Eleven of the minor tributaries are believed to supply insignificant quantities of sediment to the John Day Pool. Thirteen of the tributaries are believed to trap the majority of the sediment at their outlet by culverts. This leaves a total of 7 tributaries that directly contribute sediment to the John Day Pool. The total drainage area of these 7 tributaries is approximately 716 square miles. This is a total contribution of approximately 243,000 tons per year. If we assume that bed load transport is roughly 10 percent of the suspended load, then an average contribution of 24,000 tons per year is expected to be transported to the Columbia River.

Table 4-3: Minor tributary sedimentation observations.

TRIBUTARY	DRAINAGE AREA	EXISTING STRUCTURE	1955 MAP OBSERVATIONS	1999 FIELD OBSERVATIONS
GLADE CREEK	347	Bridge	Significant delta deposits	Sediment source to reservoir, backwater deposits
ALDER CREEK	197	Bridge	Significant delta deposits	Sediment source to reservoir, backwater deposits
SIXMILE CANYON	144	CMP - 2	Minor delta deposits	Minor amount of sediment in culvert, no backwater
FOURMILE CANYON	91.4		No significant deposition observed	Unable to locate, is likely out of backwater
DEAD CANYON	76.9	Bridge	Alluvial fan, channel did not reach Columbia River	Sediment source to reservoir, backwater deposits
WOOD GULCH	63.8	Bridge	Large alluvial fan and delta	Sediment source to reservoir, backwater deposits
PINE CREEK	58.7	CMP - 3	Significant delta deposits	Majority of Sediment trapped u/s of hwy 14
CHINA CREEK	49.8	Bridge	No significant deposition observed	Sediment carried through concrete channel likely deposited in backwater
NO NAME 11 (Sumner Ranch Cr.)	42.6	Bridge	Moderate alluvial fan and delta	No significant sedimentation observed, no backwater at bridge, dry wash
CHAPMAN CREEK	24.1	Bridge	Moderate delta deposits	Sediment source to reservoir, backwater deposits, majority of sediment trapped u/s of RR bridge
OLD LADY CANYON	19.2	CMP - 1	Minor delta deposits	Minor sand deposits at culvert outlet, no backwater
BLALOCK CANYON	16.9	CMP - 2	Significant deposits in channel below mouth, river channel widens at this location	Two sediment/debris dams located u/s of culvert inlet, no backwater

Table 4-3 (continued):

JONES CANYON	14.9	CMP - 1	Minor delta deposits	No significant sedimentation observed, no backwater at I-84 culvert
HELM CANYON	8.58	CMP - 3	Minor delta deposits	Minor amount of sediment trapped u/s of culverts, no backwater
THREEMILE CANYON	7.15	CMP - 1	No significant deposition	Culvert partially filled with sediment, no backwater
LANG CANYON	6.52	CMP - 2	No significant deposition	Sediment trapped in pond u/s of culvert, no backwater from reservoir
NO NAME 1	5.10	CMP - 1	No significant deposition	Sediment source to reservoir, culvert partially filled with sediment, small delta below culvert oulet, no backwater at culvert
MYERS CANYON	4.84	CMP - 2	Small alluvial fan	Some bed material in culverts, very angular - local source, no backwater
SAND SPRING CANYON	4.83	CMP - 1	Moderate alluvial fan and delta deposits	Sediment source to reservoir, culvert partially filled with sediment, small delta below culvert oulet, no backwater at culvert
PHILLIPI CANYON	4.76	CMP - 2	No significant deposition	Minor amount of sediment trapped u/s of culverts, no backwater
JU CANYON	2.78	CMP - 1	Moderate alluvial fan with minor delta deposits	Sediment source to reservoir, culvert partially filled with sediment, small delta below culvert oulet, no backwater at culvert
SWANSON CREEK	2.45	CMP - 1	Small alluvial fan and delta	Steep hillslope u/s of culvert, alluvial fan of coarse material from hillslope, some finer sediment deposits u/s of inlet, no backwater
NO NAME 6	1.68	CMP - 1	No significant deposition	No significant sedimentation observed, no backwater at culvert
NO NAME 10	1.59	CMP - 1	No significant deposition	Minor amount of sediment in culvert, no backwater
NO NAME 8	1.51	RCB - 1	No significant deposition	No significant sedimentation observed, no backwater at culvert

Table 4-3 (continued):

NO NAME 7	1.17	CMP - 1	No significant deposition	No significant sedimentation observed, no backwater at culvert
NO NAME 5	1.16	CMP - 1	No significant deposition	No significant sedimentation observed, no backwater at culvert
NO NAME 2	1.00		Minor delta deposits	No access, likely out of backwater, likely not significant source of sediment
NO NAME 3	0.93	CMP - 2	Minor delta deposits	Culverts half full of sediment, no backwater
NO NAME 4	0.81	CMP - 1	No significant deposition	No significant sedimentation observed, no backwater at culvert, debris fence installed u/s of culvert inlet
NO NAME 9	0.77		No significant deposition	Unable to locate, is likely out of backwater

5. REQUIREMENTS FOR CHANNEL MODIFICATION

Sediment deposition within the tributary channels due to backwater from the John Day Pool has significantly changed the geometry on several of the tributary streams. To insure the continuous passage of migrating adult fish in these tributaries, modifications to the current channel geometry are required. The required modifications were developed based on design channels developed to transport the incoming sediment loads and pass adult fish. To determine the channel design requirement for sediment transport, the Copeland Method (1994) was used. The newly designed channel was then input into HEC-RAS to determine channel hydraulics for fish passage.

5.1 Fish Passage Impacts

The major impact of the proposed drawdown to fish species would be the creation of a barrier to upstream adult salmonid migration. The sediments that have accumulated in the tributaries inhabited by anadromous fish since the creation of the John Day Pool could cause a blockage to fish is if not sufficiently modified prior to drawdown. These blockages could be in the form of velocity barriers and/or depth barriers.

5.2 Erosion/Sedimentation Issues

After the drawdown takes place, the tributaries will begin to readjust to the new boundary conditions. The river will reshape any channel modified to pass fish and transport sediment. This may cause areas of erosion and/or deposition in the channel and along the banks. The tributary channels will need to be monitored and it is expected that some modifications will be required as the channel reshapes itself. An extensive erosion control plan should be implemented to protect the newly exposed riverbanks.

5.3 Hydraulic Analysis

Hydraulic models of the John Day River, Willow Creek, Rock Creek, and Umatilla River were developed for existing topographic conditions. The developed models were used to define the characteristics of the depth and velocity of flow along each stream for each of the proposed drawdown conditions. The minimum and maximum average monthly flow associated with the adult migration period of involved fish species was evaluated for the natural and spillway freeflow drawdown scenarios (see Table 3-2). The hydraulic conditions for each stream were evaluated to identify fish passage barriers that may be expected without channel modifications (see Table 3-4 and Table 3-5). Accordingly, the extent and type of required channel modifications have been identified.

5.4 Stable Channel Design

Fish passage requirements determine the need for channel modifications. On the four main tributaries that pose a barrier to fish, a stable channel design was developed. The stable channel design option in SAM uses the Copeland Method (1994) to develop stable channels based on incoming sediment loads, bed material size distributions and channel forming discharge. Estimates of channel width and slope for the four main tributaries were developed using the 2-

year flood event. Design channel configurations are given in Table 5-1. The design channels were input into HEC-RAS and modeled to check velocities and depths for fish passage using the flows from the fish passage analysis found in Table 3-2. Modifications made in HEC-RAS to the channel geometry and slope were input back into SAM to determine the sediment transport capacity of the design channel. Stable channel cross sections and profiles with water surface elevations for the four major tributaries are shown in Attachment C. Design channels were developed based on a trapezoidal cross section with 2h: 1v side slopes. Bottom widths and channel slopes were determined from the Copeland Method and from pre-dam channel geometry. The design channels all contain a low flow channel either a "V" shaped or trapezoidal shaped notch to allow for fish passage under the lowest average flow conditions.

Table 5-1: Design channel configurations.

Tributary	Bottom Width (feet)	Side Slope (h:v)	Channel Slope (ft/mile)
Willow Creek	65	2:1	0.004
Umatilla River	195	2:1	0.005
Rock Creek	67	2:1	0.0086

5.4.1 John Day River

A stable channel design for fish passage on the John Day River was not developed. At locations of potential barriers, the channel slope becomes the limiting factor in the hydraulics. A design that would reduce the channel slope could not be made due to observed upstream bedrock control at river mile 4.5 shown in the topographic maps and river profiles. Also, the relatively narrow confines of the valley walls would not allow introduction of meanders to reduce the existing channel slope. Additionally, the comparison of thalweg profiles shown in Figure 4-1 shows no noticeable change in channel profile between pre-and post-dam conditions.

Cross section of concern for fish passage were checked against pre-dam (1955) cross sections to determine what changes may have occurred in the geometry that would affect fish passage. It was determined that no significant changes had occurred that would affect fish passage. A selected cross section location showing pre- and post-dam geometry is shown in Figure 5-1. An additional HEC-RAS model was developed from the pre-dam (1955) geometry data to test for potential blockages. When the same fish flows used in the post-dam geometry model were run in the pre-dam model, similar locations showed potential blockages to fish. It was concluded that sedimentation in the channel has not introduced additional fish passage concerns. Therefore, dredging on the John Day River is not recommended.

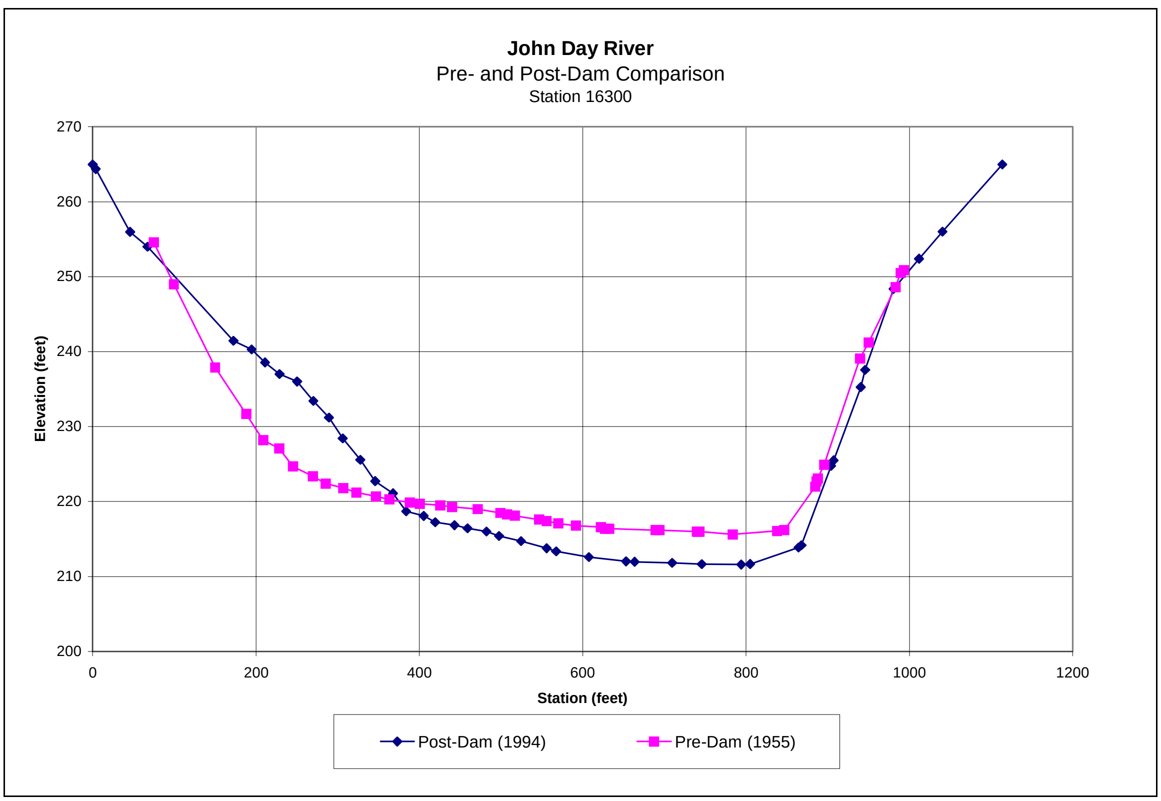


Figure 5-1: Selected cross section comparison of John Day River (location determined to be potential barrier to fish passage in hydraulic models).

5.4.2 Willow Creek

Willow Creek has a significant amount of sediment deposition within the backwater of the John Day Pool. In some locations there is as much as 40 ft of deposition, but typically average 20 feet. A design channel was developed to transport the existing incoming bed material load. The new channel has a similar slope and geometry to the channel that existed prior to the John Day Dam.

Significant quantities of sediment will be exposed under the proposed drawdown conditions. This newly exposed sediment will be subject to erosion from precipitation, overland flow, and channel processes. Due to the significant depth of required sediment removal necessary to incorporate the design channel, it is expected that localized erosion will contribute significant amounts of sediment to the channel. The largest amounts of which will be contributed during the first few years after the drawdown takes place and should gradually reduce as vegetative cover increases and local sediment supplies decrease. Erosion control measures and channel maintenance will be necessary to maintain fish passage on Willow Creek. A selected cross section for Willow Creek showing pre-dam, post-dam and design channel geometry is shown in Figure 5-2.

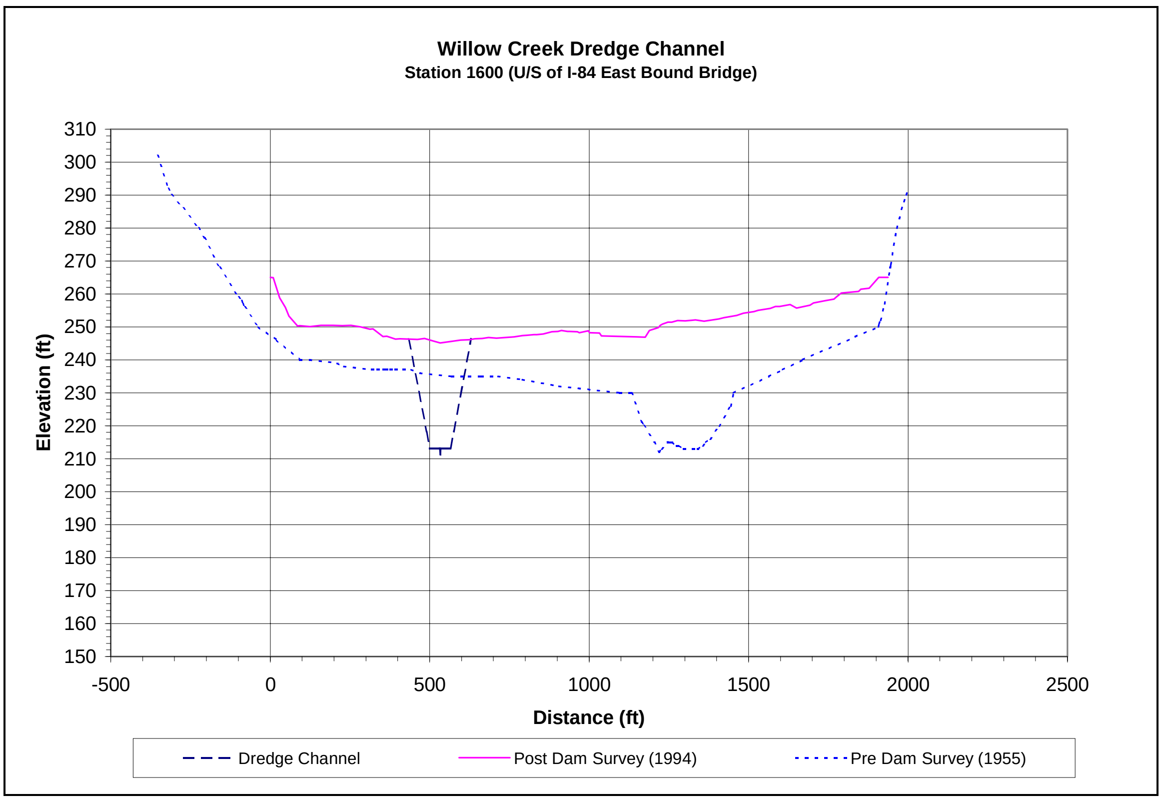


Figure 5-2: Selected pre-dam, post-dam and design channel cross sections for Willow Creek.

5.4.3 Umatilla River

The Umatilla River is controlled by bedrock at approximately River Mile 2. Above this location is the Three Mile Falls diversion dam. It has a hydraulic height of 23 ft and crest length of 915 feet. This dam along with numerous other storage and diversion dam within the Umatilla Basin has effectively cut off the supply of bed material to the mouth of the Umatilla River. This observation is supported by the relatively minor amount of sediment accumulation in the channel between 1955 and 1994. Modifications to the current channel are minor, and typically provide for a low flow channel to allow for fish passage during the lowest average flows. A selected cross section showing the current channel and design channel geometry are shown in Figure 5-3

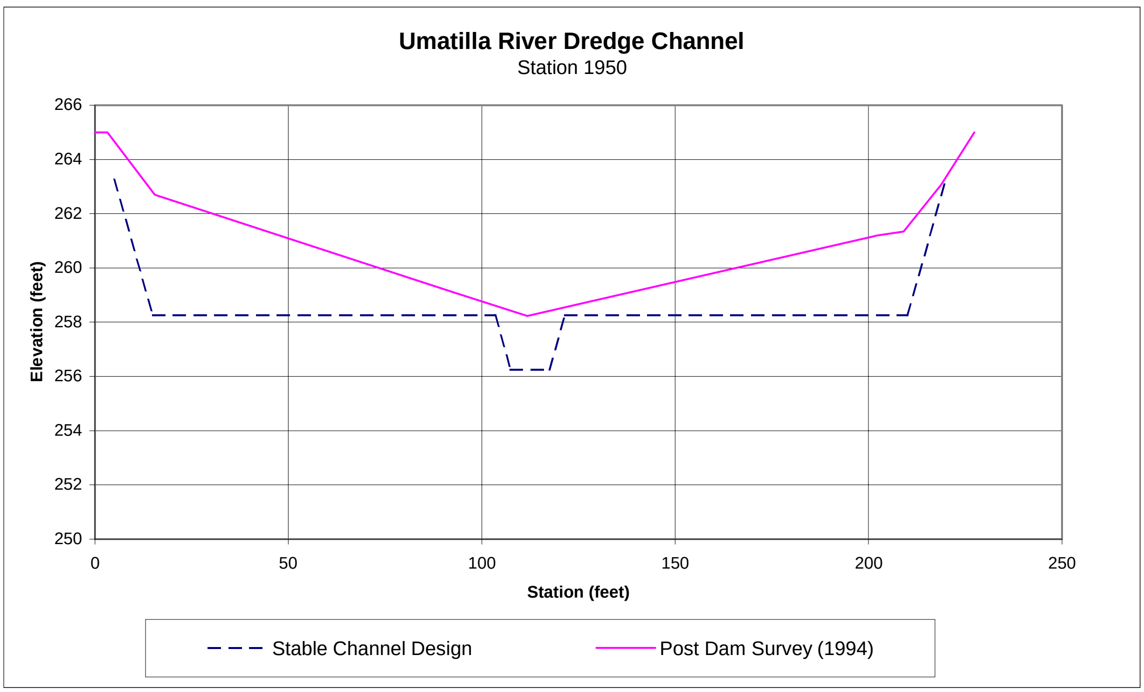


Figure 5-3: Selected post-dam and design channel cross sections for the Umatilla River.

5.4.4 Rock Creek

It was determined that the modifications must be made to the outlet of Rock Creek to incorporate the stable channel design that will provide for fish passage. A new outlet located along the centerline of the channel is recommended. The outlet would be cut through the existing road bed fill and spanned by a new highway bridge and railroad bridge. The new channel alignment would closely approximate pre-dam conditions and allow for sediment transport beyond the current outlet location.

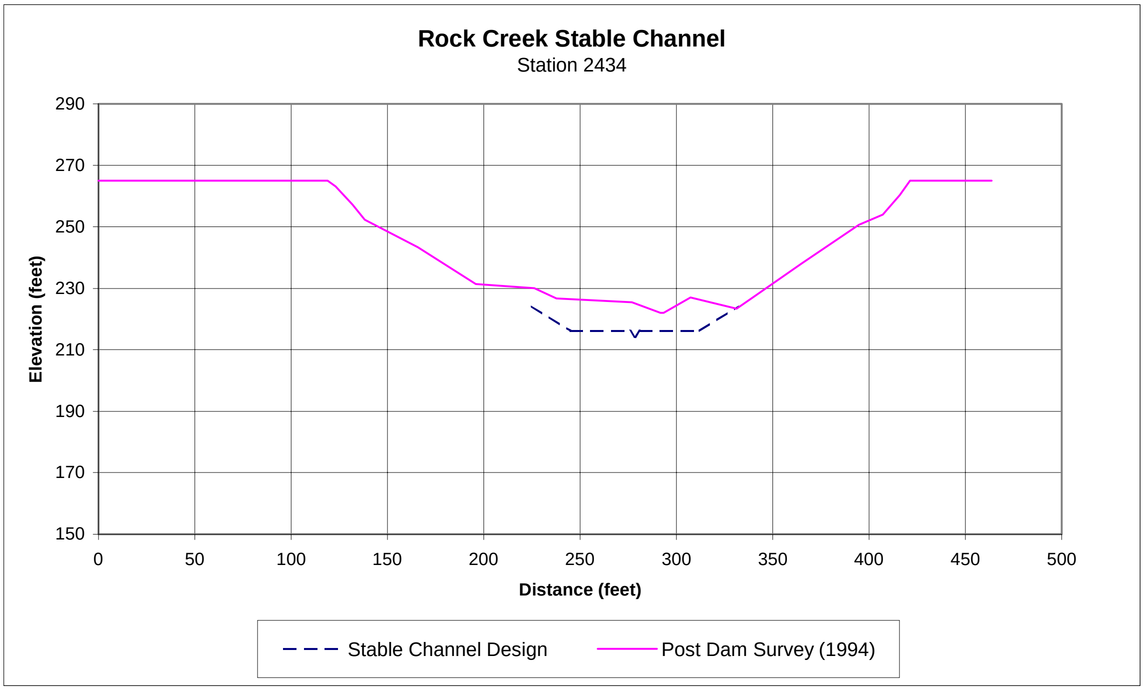


Figure 5-4: Selected post-dam and design channel cross sections for Rock Creek.

5.4.5 Wood Gulch

Wood Gulch is a gravel and cobble bed stream. It is the only other tributary to the John Day Pool known to support salmonids. However, no data are available to determine requirements for fish passage. It is likely that some dredging of the delta may be required to initially open the stream to fish passage. However, it is also likely that the channel will quickly adjust to the new conditions and maintain itself. It is unlikely that continued maintenance will be required.

6. DREDGING REQUIREMENTS

Initial dredging of Willow Creek, Umatilla River, Rock Creek, and Wood Gulch will be required to open the channel to adult fish passage under the proposed drawdown conditions. Initial dredging is that amount of dredging required to provide for fish passage. After initial dredging is completed and drawdown takes place, the channel will begin to readjust itself to the new hydraulic and sediment transport conditions. As this adjustment takes place, maintenance dredging may be required on an annual basis to maintain the design channel. The amount of maintenance required will depend on the ability of the channel to transport the incoming sediment load. In some cases, the incoming sediment load will be increased by local bank erosion from the newly exposed sediments. Bank stability measures located at select locations will reduce the amount of required maintenance dredging.

6.1 Initial Dredging

The stable channel cross sections were overlaid on the existing cross sections to measure the amount of sediment to be removed (in square feet). This was done for each cross section where data was available. The average end area method was used to determine the volume of sediment required to be removed. Dredge quantities are “in-place” volumes. This means that no adjustments have been made to the quantities to account for changes in density, which is commonly referred to as “bulking”. Dredge quantities are shown in Table 6-1.

Cross section data for Willow Creek did not extend far enough upstream to compute the entire dredge quantity. The additional dredge quantity was estimated using average end area method between the most upstream cross section and the intersection of the backwater with the channel.

Table 6-1: Initial dredging quantities.

Tributary	Dredge Quantity	
	Spillway (Yd^3)	Natural (Yd^3)
John Day	0	0
Willow Creek	468,382	1,051,755
Umatilla River	41,768	41,768
Rock Creek*	53,431	377,275
Wood Gulch	Unknown (no data)	Unknown (no data)

* Quantities exclude roadbed fill removal

6.2 Maintenance Dredging

John Day River does not require maintenance dredging since no initial dredging is recommended. The Umatilla River is also not expected to require maintenance dredging. The sediment transport capacity of the Umatilla River under spillway freeflow and natural drawdown conditions is in excess of the incoming sediment load. This will maintain the dredge channel or possibly cause additional degradation.

The stable channels designed for Willow Creek and Rock Creek are designed to transport the incoming sediment load. However, the dredged channels will be highly entrenched within the existing sediments. These sediments will be subject to erosion rates the first several years after drawdown occurs. For this reason, maintenance-dredging quantities for natural conditions were assumed to equal the incoming sediment load to account for channel migration and side slope erosion. For spillway conditions, this quantity for natural conditions was scaled by the ratio of the dredging depths ([spillway depth/natural depth]*natural dredge quantity) where * is a multiplication factor. Maintenance dredging quantities for the four major tributaries are summarized in Table 6-2. Again, these quantities do not account for bulking.

Table 6-2: Average annual maintenance dredging quantities.

Tributary	**Dredge Quantity**	
	Spillway (Yd^3)	Natural (Yd^3)
John Day	0	0
Willow Creek	70,000	106,000
Umatilla River	0	0
Rock Creek	6,000	19,000
Wood Gulch	Unknown (no data)	Unknown (no data)

6.3 Dredge Spoil Disposal

An assumed disposal depth of 15 ft and bulking factor of 1.5 was used to estimate the aerial extent of the dredge disposal. The volume of dredge material determined for initial and maintenance dredging was increased by a factor of 1.5 to account of bulking. The bulked volume was then divided by the assumed disposal depth of 15 ft to estimate the extent of the disposal area. Disposal areas are summarized in Table 6-3.

Table 6-3: Dredge spoil disposal area.

Tributary	**Disposal Area**			
	Spillway Alternative		Natural Alternative	
Initial Dredging	(ft^2)	(acres)	(ft^2)	(acres)
John Day	0	0	0	0
Willow Creek	1,264,631	29.0	2,839,739	65.2
Umatilla River	112,774	2.6	112,774	2.6
Rock Creek	144,264	3.3	1,018,643	23.4
Wood Gulch	Unknown (no data)	Unknown (no data)	Unknown (no data)	Unknown (no data)
Maintenance Dredging				
John Day	0	0	0	0
Willow Creek	189,000	4.3	286,200	6.6
Umatilla River	0	0	0	0
Rock Creek	16,200	0.4	51,300	1.2
Wood Gulch	Unknown (no data)	Unknown (no data)	Unknown (no data)	Unknown (no data)

7. SUMMARY

In the preceding sections a reconnaissance-level evaluation of tributary sedimentation issues associated with two proposed drawdown alternatives for the John Day Dam was presented. The conditions of sedimentation within all significant streams tributary to the existing John Day pool were defined. Major tributaries with topographic and sediment data include the John Day River, Willow Creek, and Umatilla River on the Oregon shore, and Rock Creek on the Washington shore.

An evaluation of sediment transport characteristics of the tributaries to the John Day Pool was made to understand how they would be impacted by proposed drawdown conditions. The evaluation included both qualitative and quantitative assessments of sediment transport conditions. Annual sediment budgets were developed for the John Day River, Willow Creek, Umatilla River, and Rock Creek. Due to data availability, quantitative analyses were limited to these four major tributaries. Estimates of the combined average annual sediment input to the John Day project reach were extrapolated from results defined for the four major tributaries.

The possible impacts of each drawdown scenario to the five tributaries considered important for fish habitat (John Day River, Umatilla River, Willow Creek, Rock Creek and Wood Gulch) were analyzed. Hydraulic models of the tributaries were developed to evaluate potential fish passage barriers. A plan to provide fish access for these streams was formulated. Stable channel configurations were developed for Willow Creek, Umatilla River, and Rock Creek.

The initial dredging quantities required to open stable channels along three of the four of the major tributary streams (Umatilla River and Willow Creek in Oregon, and Rock Creek in Washington) to upstream fish passage were estimated. Wood Gulch is also expected to require dredging to ensure fish passage; however, no quantitative estimates could be developed due to data limitations. Dredging quantities greater than required by the stable channel design (over dredging) were included, when necessary in dredging quantity estimates. Estimates of required annual dredging to maintain fish passage in the four major tributaries to the John Day pool were also developed.

Land requirements for upland disposal of materials dredged from tributaries were evaluated. Quantity estimates were developed by tributary, to cover all immediate, short-term, and long-term dredging expectations. Aerial requirements were developed based on a bulking factor of 1.5. The identification of specific disposal sites was not made.

8. REFERENCES

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U.S. Army Corps of Engineers (USACE), Waterways Experiment Station, SAM-Hydraulic Design Package for Channels, Draft-1998.

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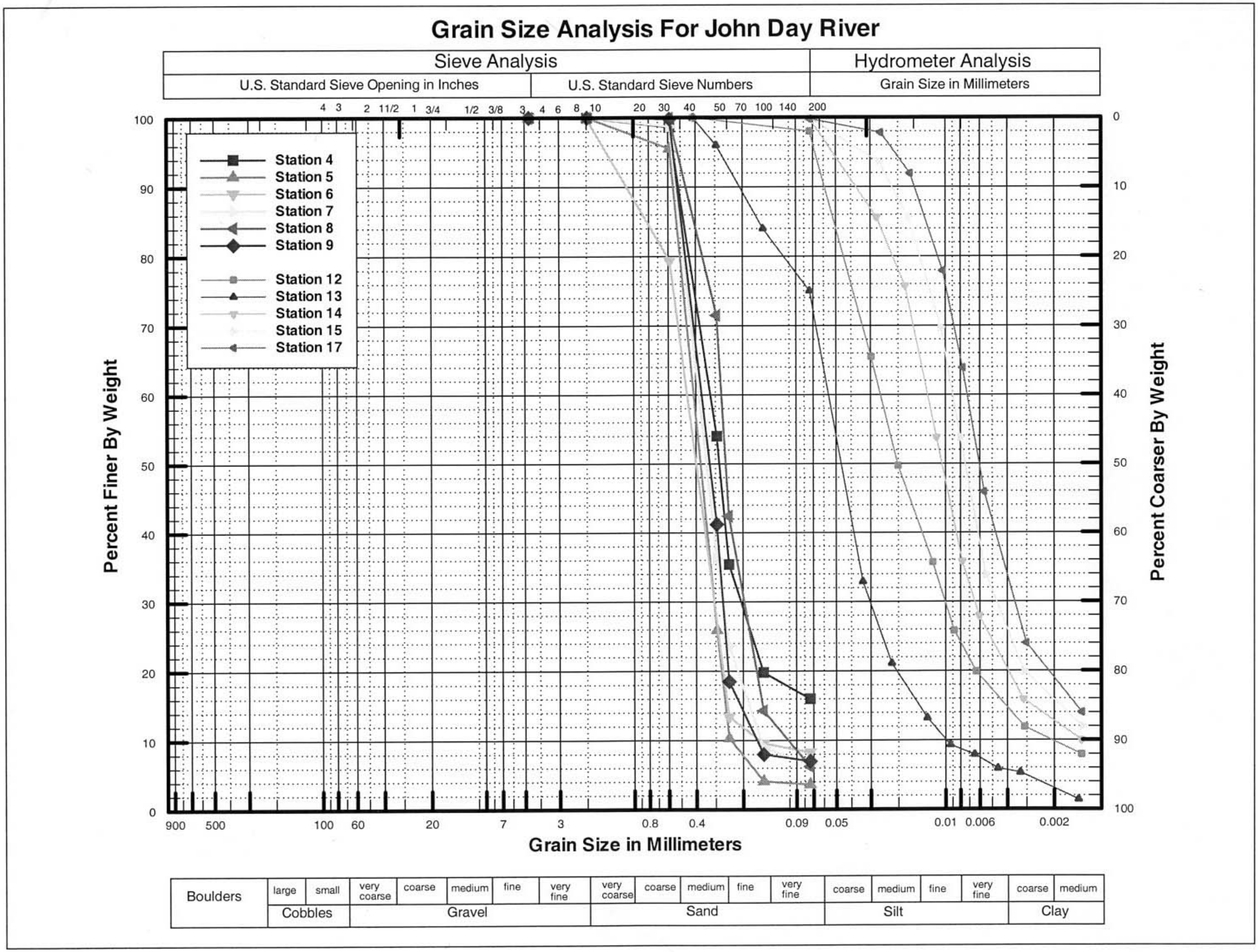
Plates

Attachment A

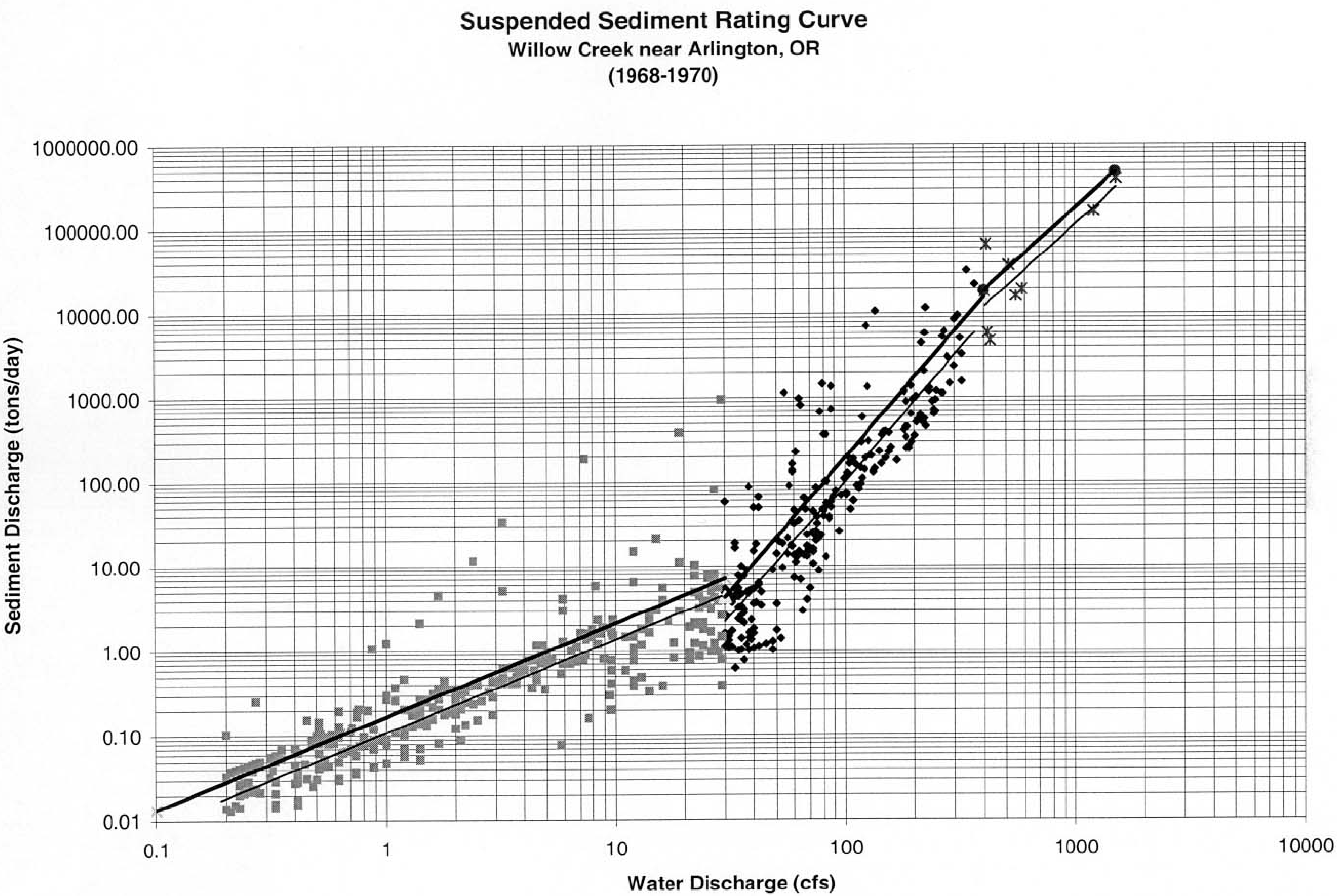
Sediment Sample Size Distributions



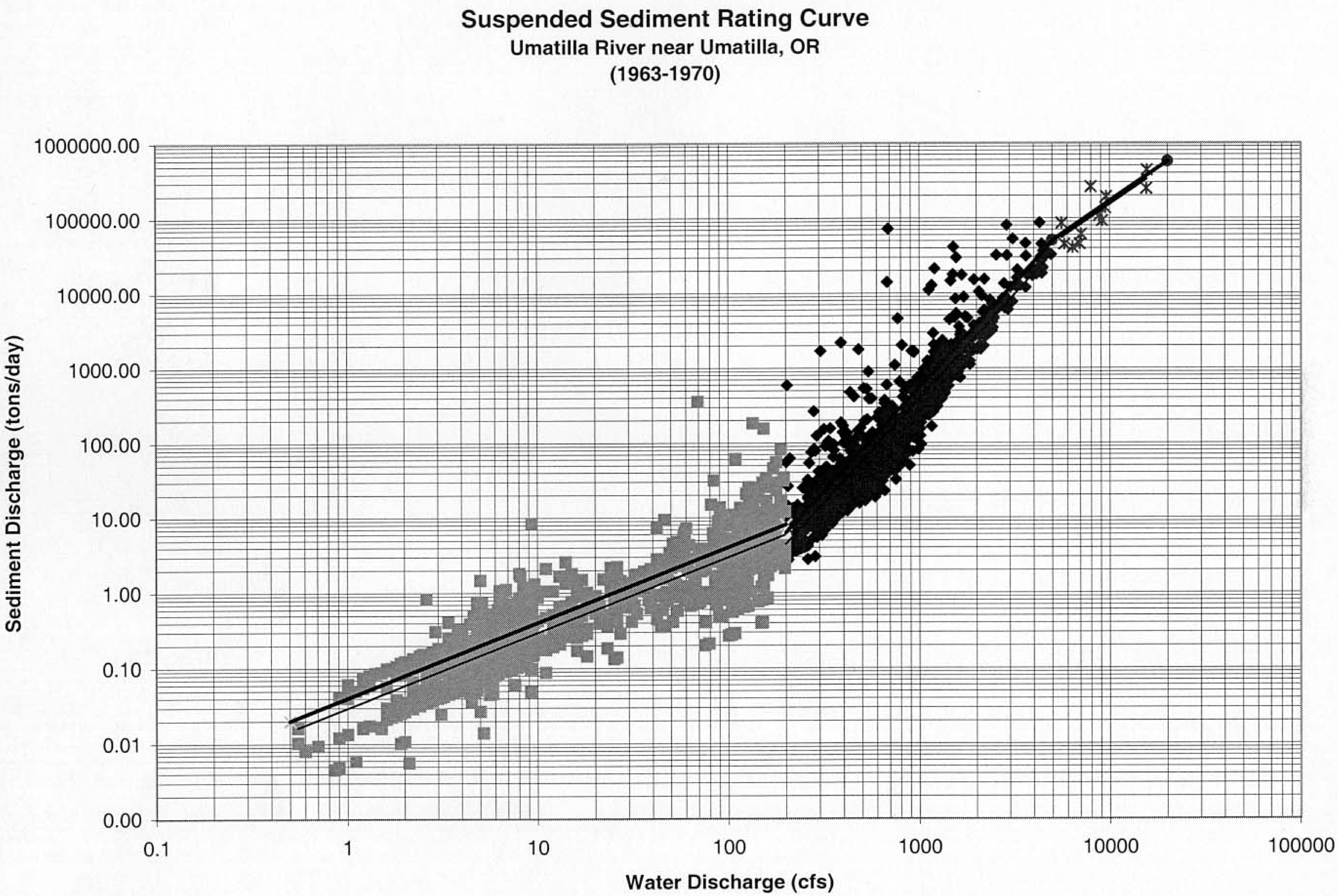
Grain Size Analysis For John Day River
Sieve Analysis
Hydrometer Analysis
U.S. Standard Sieve Opening in Inches
U.S. Standard Sieve Numbers
Grain Size in Millimeters
4 3 2 11/2 1 3/4 1/2 3/8 3 4 6 8 10 20 30 40 50 70 100 140 200
Station 4
Station 5
Station 6
Station 7
Station 8
Station 9
Station 12
Station 13
Station 14
Station 15
Station 17
Percent Finer By Weight
Percent Coarser By Weight
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
900 500 100 60 20 7 3 0.8 0.4 0.09 0.05 0.01 0.006 0.002
Grain Size in Millimeters
Boulders
large small
Cobbles
very coarse coarse medium fine very fine
Gravel
very coarse coarse medium fine very fine
Sand
coarse medium fine very fine
Silt
coarse medium
Clay

Attachment B

Tributary Sediment Rating Curves



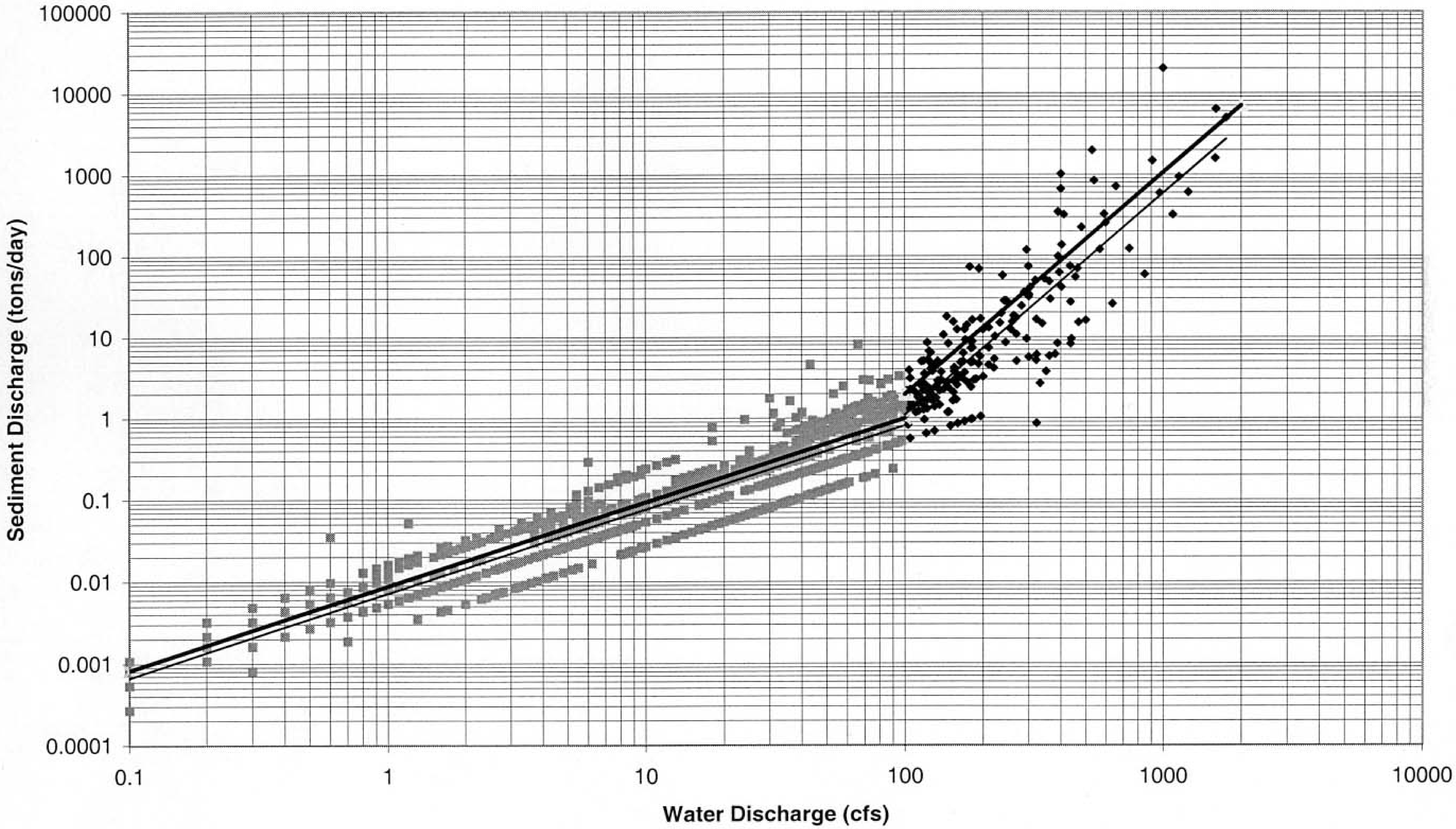
Suspended Sediment Rating Curve
Willow Creek near Arlington, OR
(1968-1970)
Sediment Discharge (tons/day)
1000000.00
100000.00
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
Water Discharge (cfs)
0.1
1
10
100
1000
10000


Suspended Sediment Rating Curve
Umatilla River near Umatilla, OR
(1963-1970)
Sediment Discharge (tons/day)
1000000.00
100000.00
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
0.00
0.1
1
10
100
1000
10000
100000
Water Discharge (cfs)

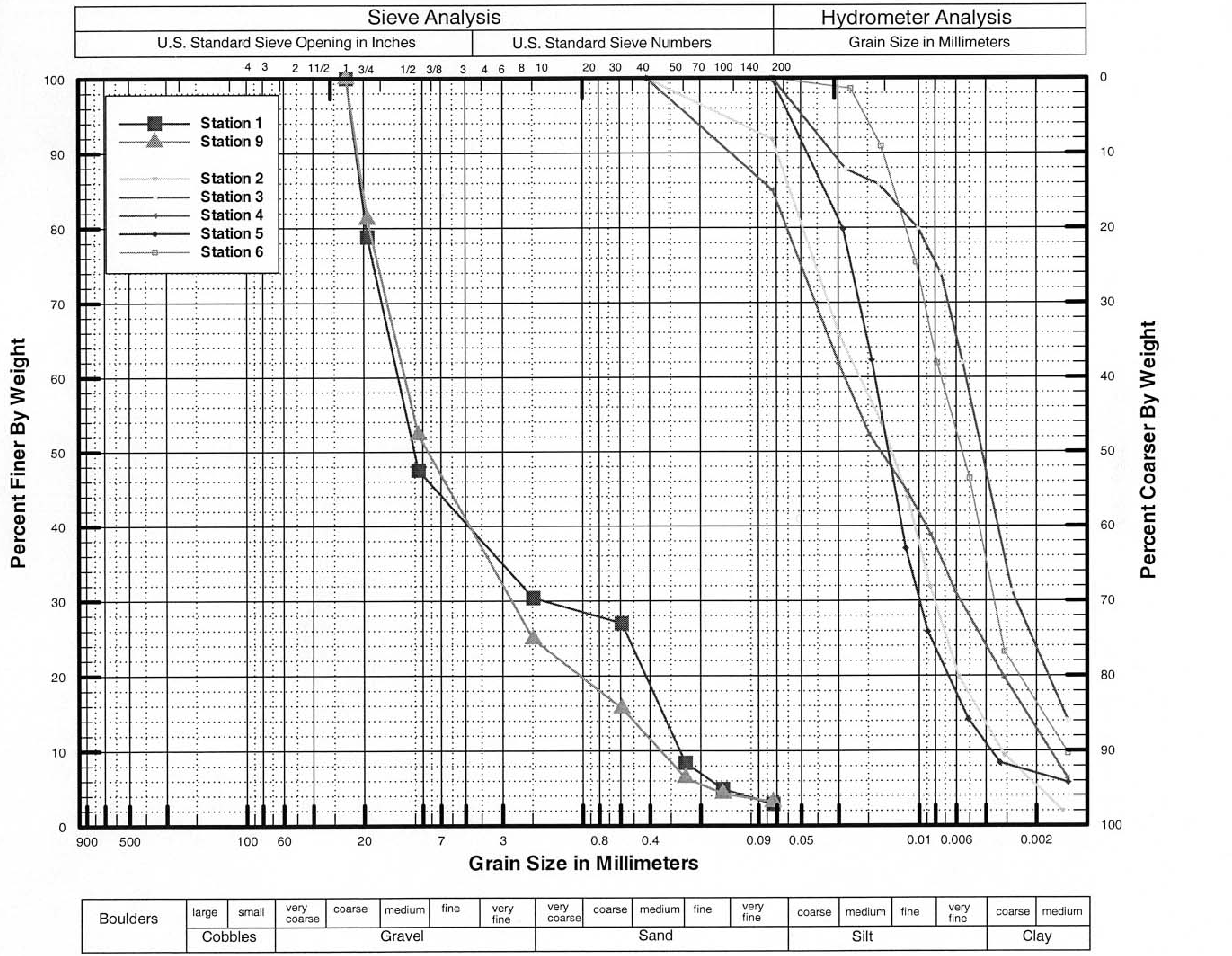
Suspended Sediment Rating Curve

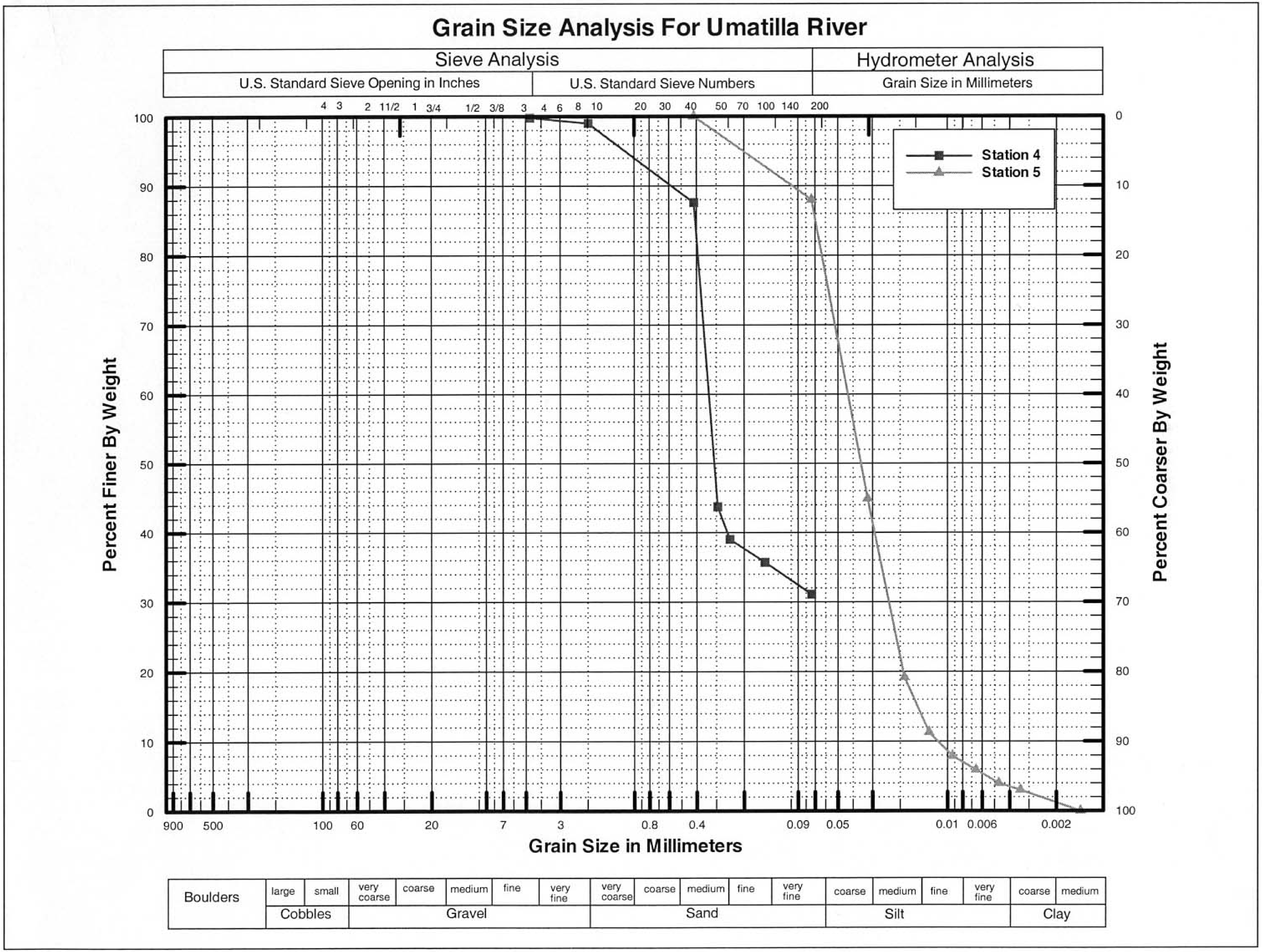
Rock Creek near Roosevelt, WA

(October 1962 - June 1968)

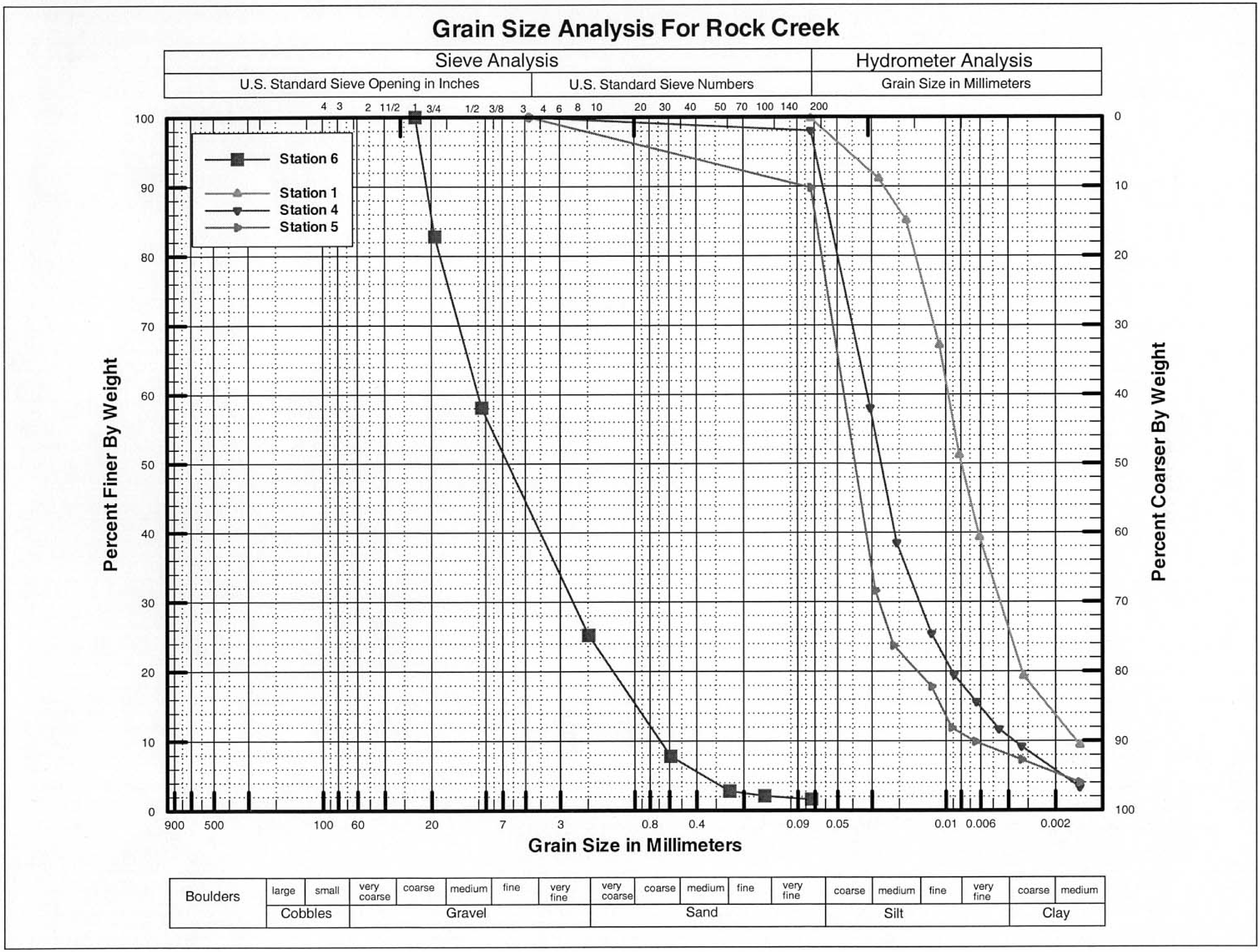


Grain Size Analysis For Willow Creek





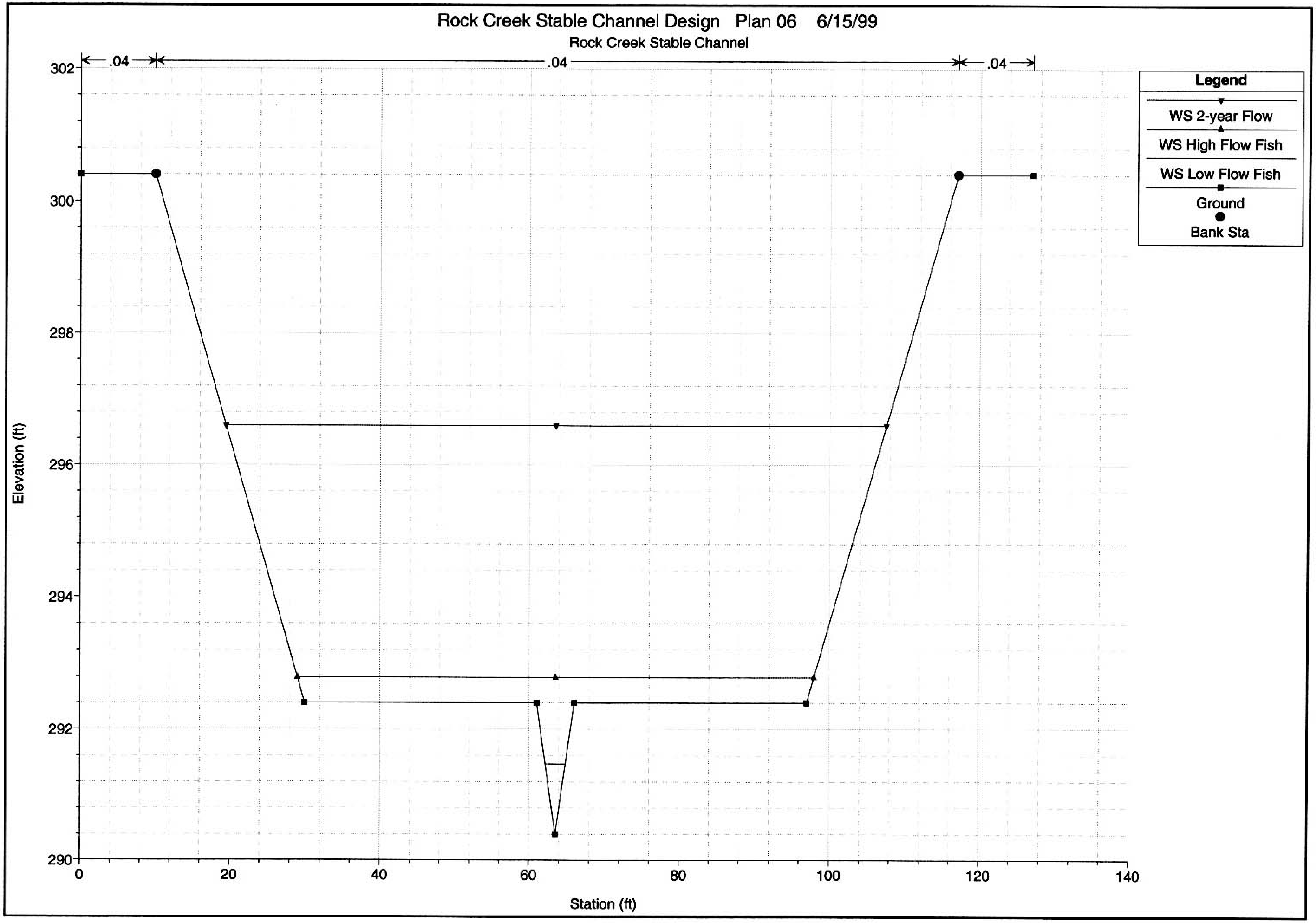
Grain Size Analysis For Umatilla River
Sieve Analysis
Hydrometer Analysis
U.S. Standard Sieve Opening in Inches
U.S. Standard Sieve Numbers
Grain Size in Millimeters
4 3 2 11/2 1 3/4 1/2 3/8 3 4 6 8 10 20 30 40 50 70 100 140 200
Station 4
Station 5
Percent Finer By Weight
Percent Coarser By Weight
100 90 80 70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
900 500 100 60 20 7 3 0.8 0.4 0.09 0.05 0.01 0.006 0.002
Grain Size in Millimeters
Boulders
large
small
Cobbles
very coarse
coarse
medium
fine
very fine
Gravel
very coarse
coarse
medium
fine
very fine
Sand
coarse
medium
fine
very fine
Silt
coarse
medium
Clay

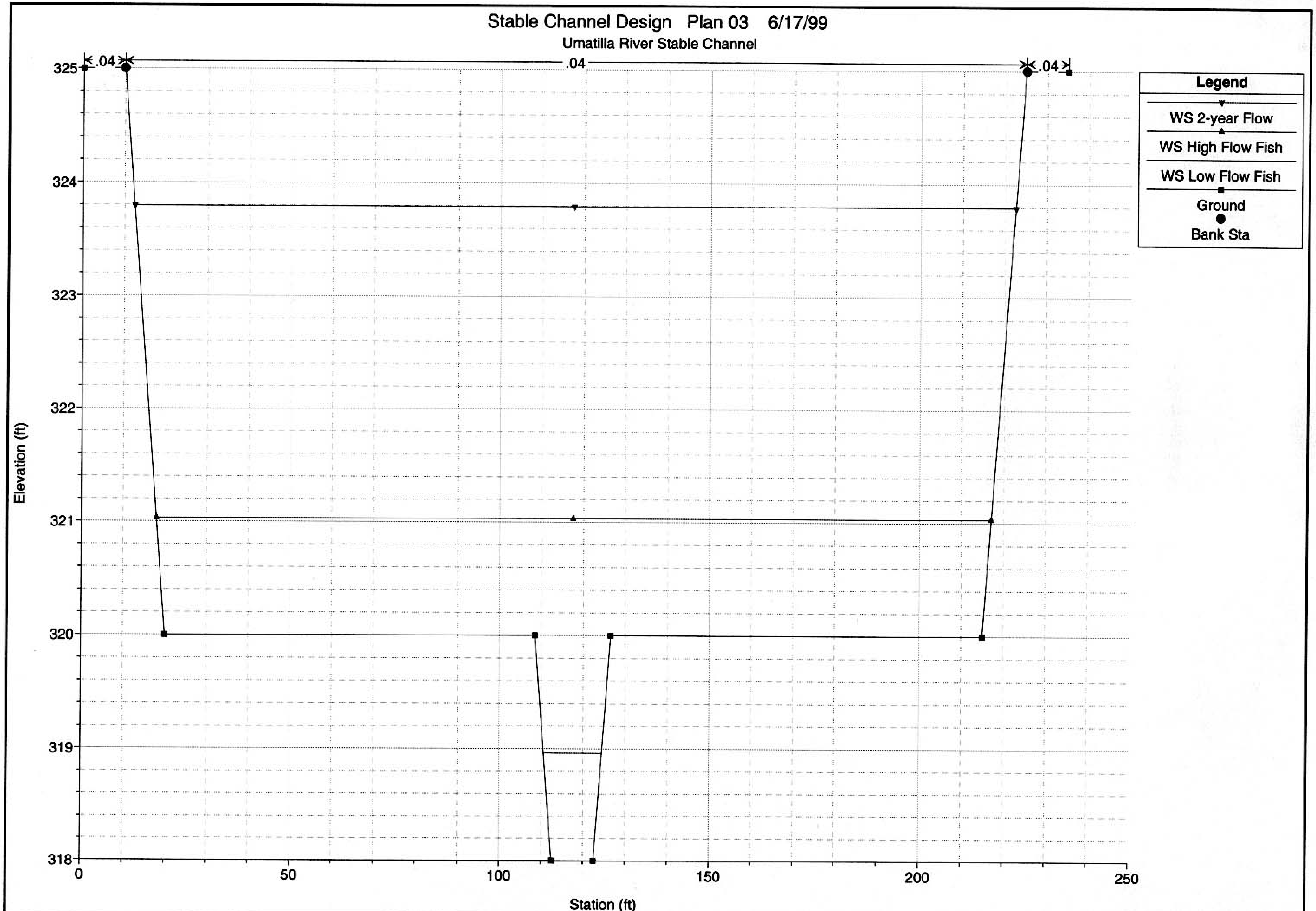


Grain Size Analysis For Rock Creek
Sieve Analysis
Hydrometer Analysis
U.S. Standard Sieve Opening in Inches
U.S. Standard Sieve Numbers
Grain Size in Millimeters
4 3 2 11/2 1 3/4 1/2 3/8 3 4 6 8 10 20 30 40 50 70 100 140 200
Station 6
Station 1
Station 4
Station 5
Percent Finer By Weight
Percent Coarser By Weight
900 500 100 60 20 7 3 0.8 0.4 0.09 0.05 0.01 0.006 0.002
Grain Size in Millimeters
Boulders
large
small
Cobbles
very coarse
coarse
medium
fine
very fine
Gravel
very coarse
coarse
medium
fine
very fine
Sand
coarse
medium
fine
very fine
Silt
coarse
medium
Clay

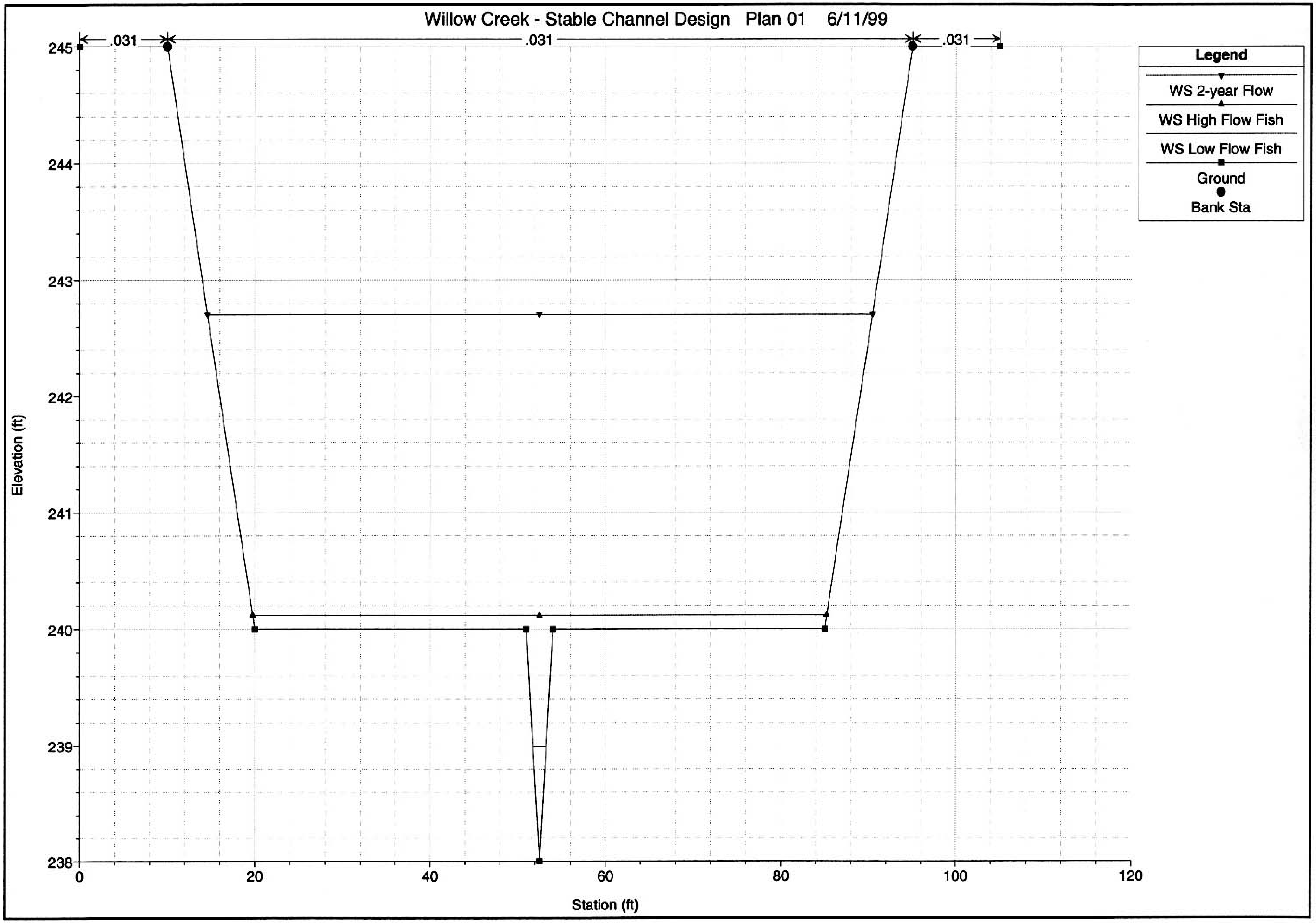
Attachment C

Stable Channel Design Cross Sections and Profiles

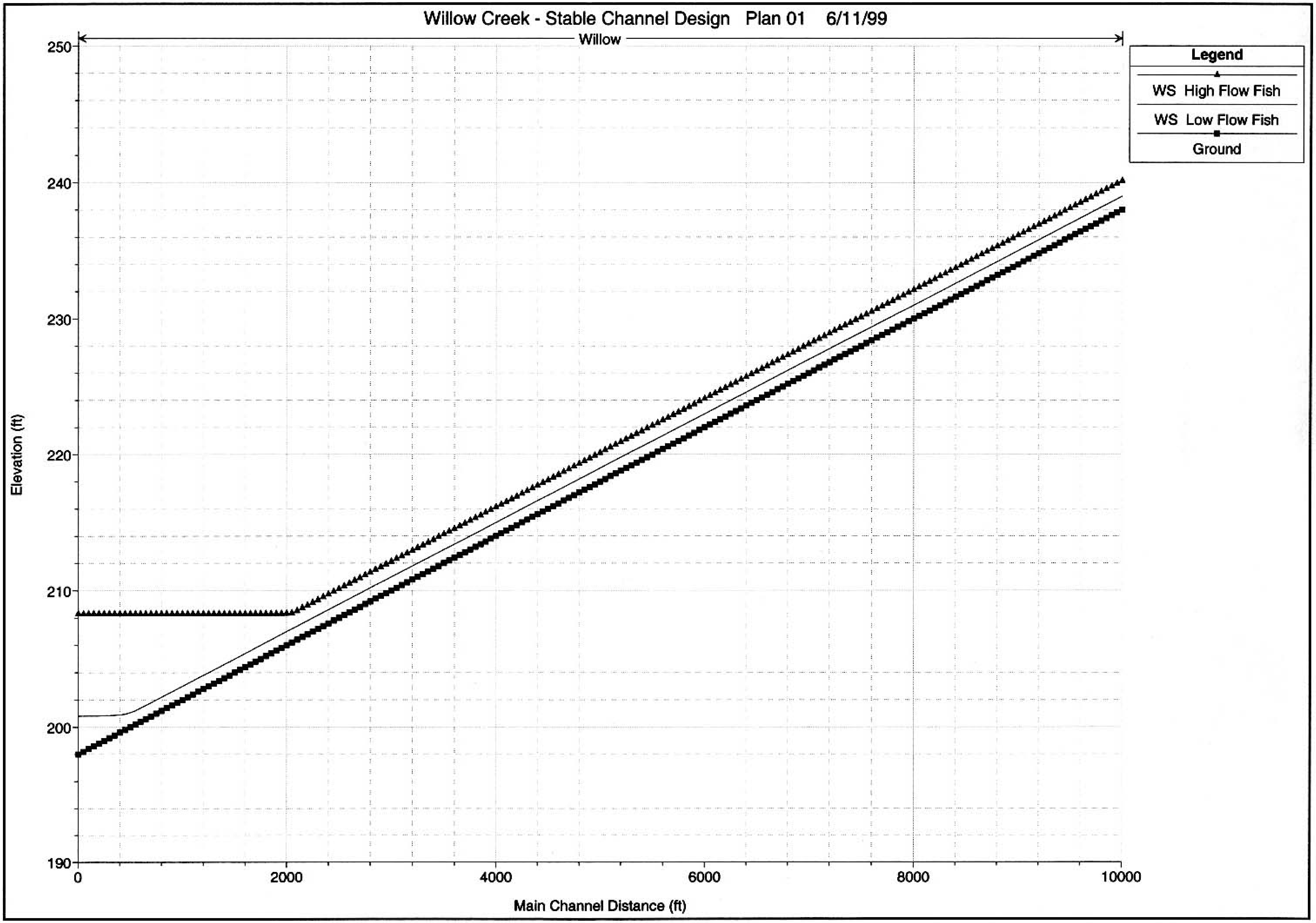

Rock Creek Stable Channel Design Plan 06 6/15/99
Rock Creek Stable Channel
.04
.04
.04
Legend
WS 2-year Flow
WS High Flow Fish
WS Low Flow Fish
Ground
Bank Sta
Elevation (ft)
302
300
298
296
294
292
290
0
20
40
60
80
100
120
140
Station (ft)

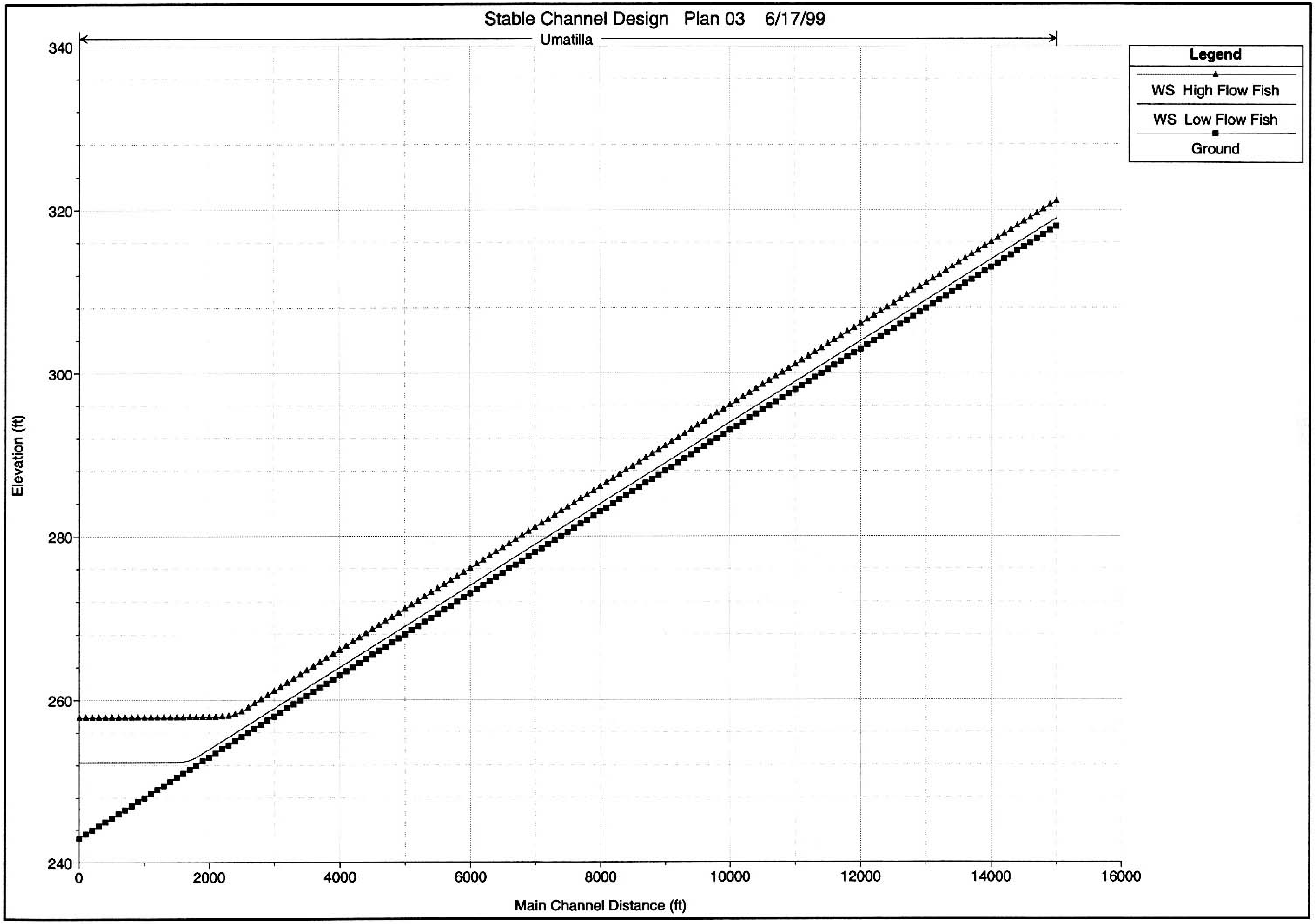


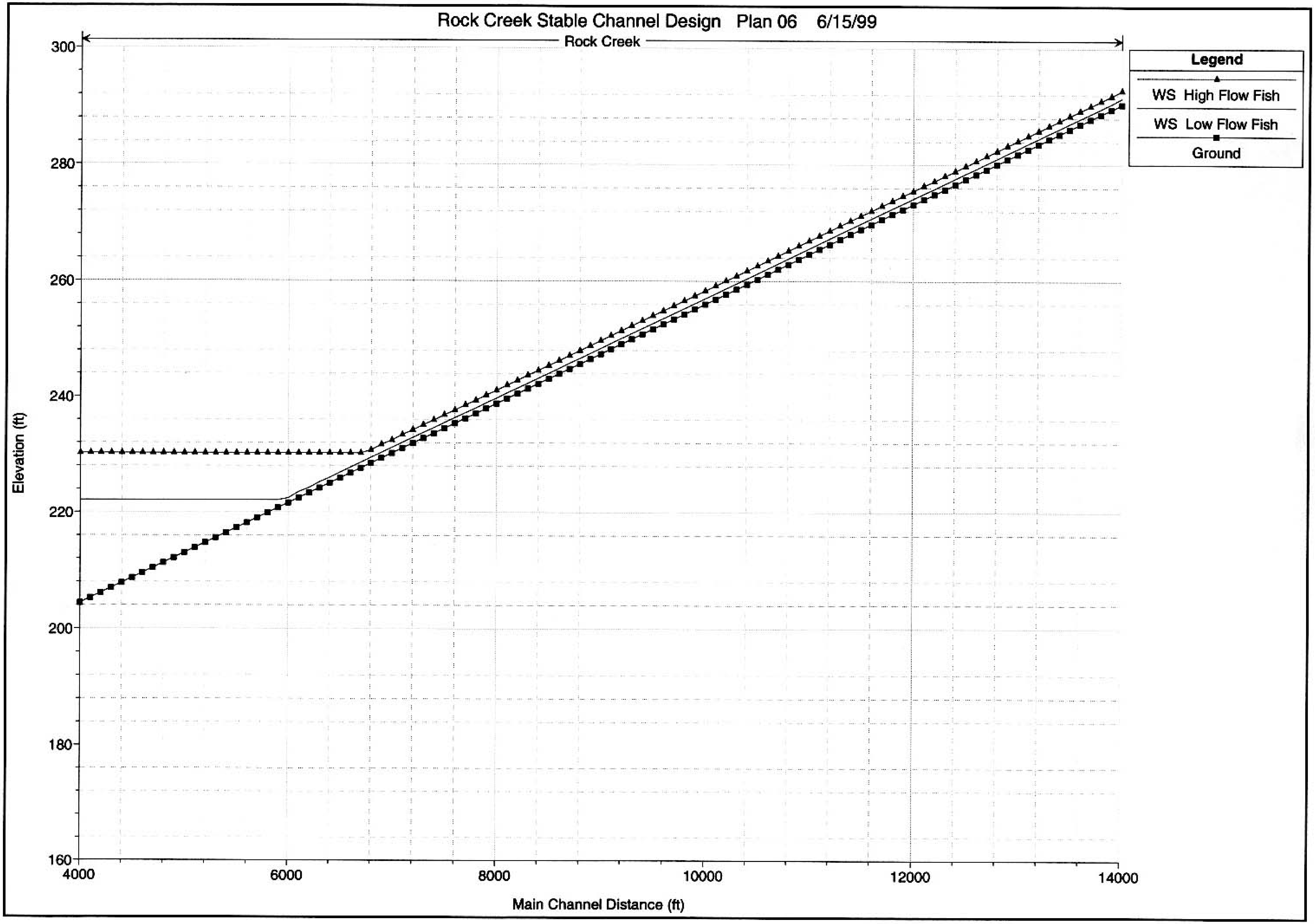
Stable Channel Design Plan 03 6/17/99
Umatilla River Stable Channel
.04
.04
.04
Legend
WS 2-year Flow
WS High Flow Fish
WS Low Flow Fish
Ground
Bank Sta
Elevation (ft)
325
324
323
322
321
320
319
318
Station (ft)
0
50
100
150
200
250



Willow Creek - Stable Channel Design Plan 01 6/11/99
.031
.031
.031
Legend
WS 2-year Flow
WS High Flow Fish
WS Low Flow Fish
Ground
Bank Sta
Elevation (ft)
Station (ft)
245
244
243
242
241
240
239
238
0
20
40
60
80
100
120

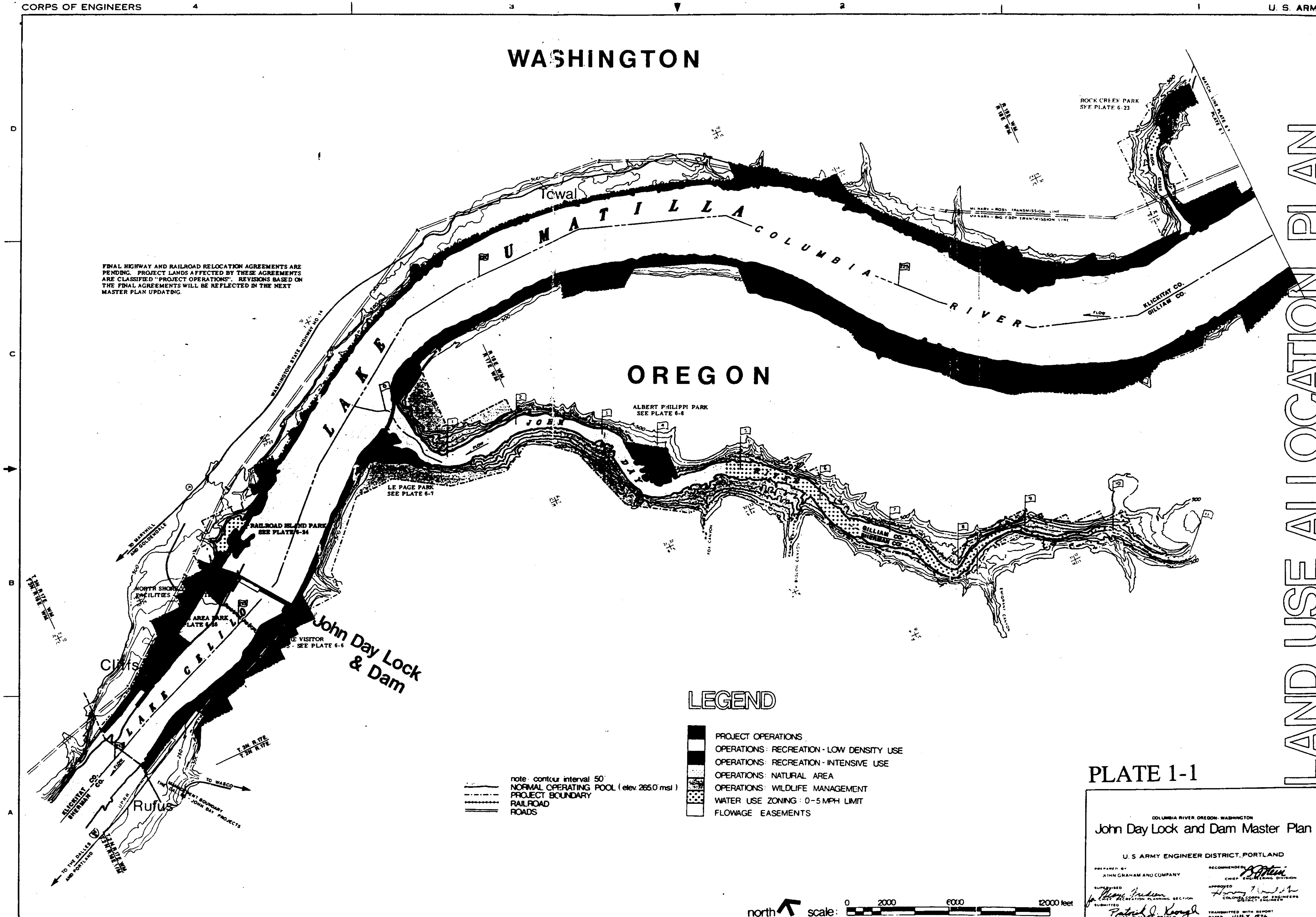

Willow Creek - Stable Channel Design Plan 01 6/11/99
Willow
Legend
WS High Flow Fish
WS Low Flow Fish
Ground
Elevation (ft)
250
240
230
220
210
200
190
0
2000
4000
6000
8000
10000
Main Channel Distance (ft)


Stable Channel Design Plan 03 6/17/99
Umatilla
Legend
WS High Flow Fish
WS Low Flow Fish
Ground
Elevation (ft)
340
320
300
280
260
240
0
2000
4000
6000
8000
10000
12000
14000
16000
Main Channel Distance (ft)


Rock Creek Stable Channel Design Plan 06 6/15/99
Rock Creek
Legend
WS High Flow Fish
WS Low Flow Fish
Ground
Elevation (ft)
300
280
260
240
220
200
180
160
4000
6000
8000
10000
12000
14000
Main Channel Distance (ft)

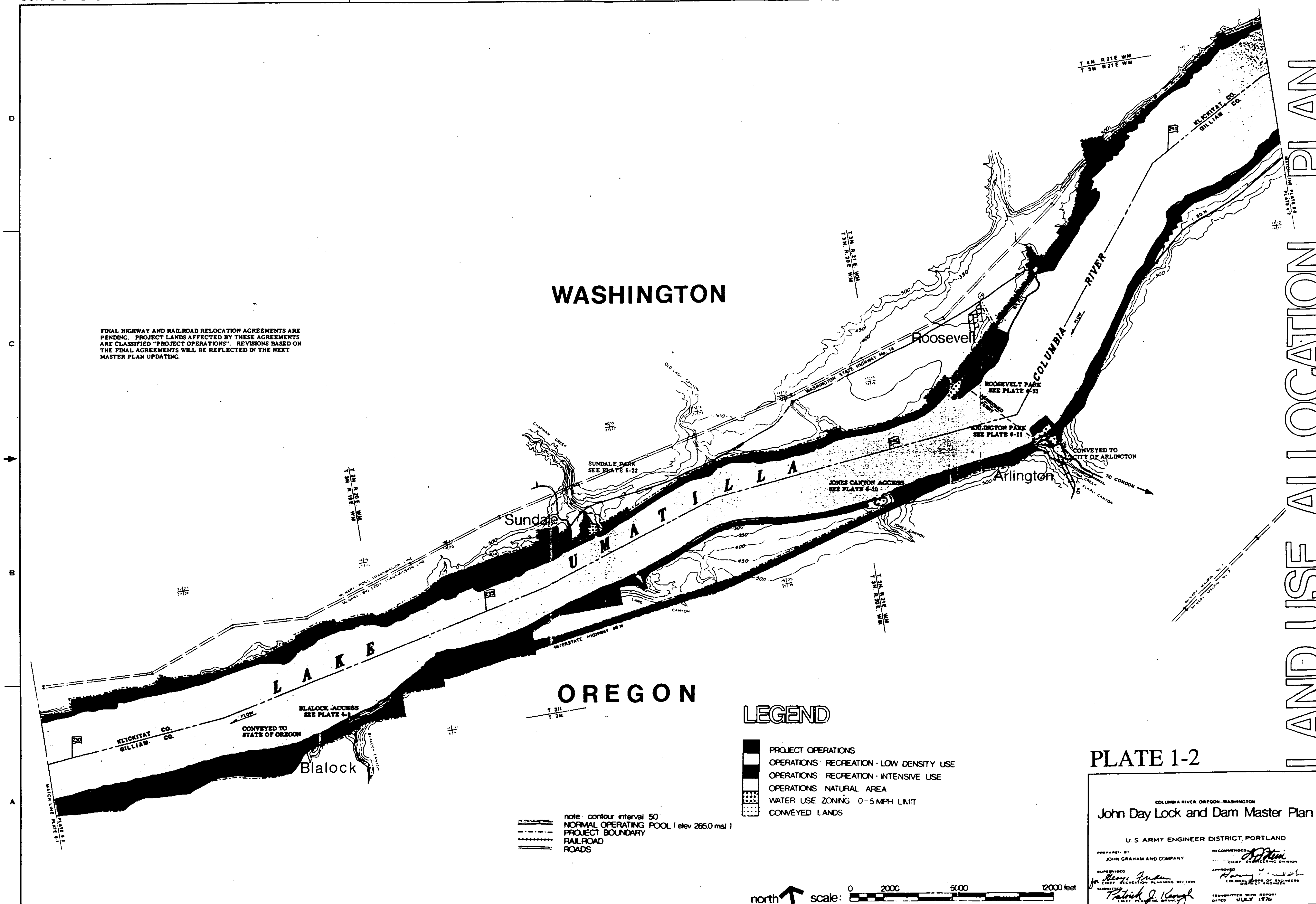
Plates

CORPS OF ENGINEERS U. S. ARMY



JD 20-2/4

LAND USE ALLOCATION PLAN



FINAL HIGHWAY AND RAILROAD RELOCATION AGREEMENTS ARE PENDING. PROJECT LANDS AFFECTED BY THESE AGREEMENTS ARE CLASSIFIED "PROJECT OPERATIONS". REVISIONS BASED ON THE FINAL AGREEMENTS WILL BE REFLECTED IN THE NEXT MASTER PLAN UPDATING.

PLATE 1-2

COLUMBIA RIVER, OREGON-WASHINGTON

John Day Lock and Dam Master Plan

U.S. ARMY ENGINEER DISTRICT, PORTLAND

PREPARED BY JOHN GRAHAM AND COMPANY

RECOMMENDED CHIEF ENGINEERING DIVISION

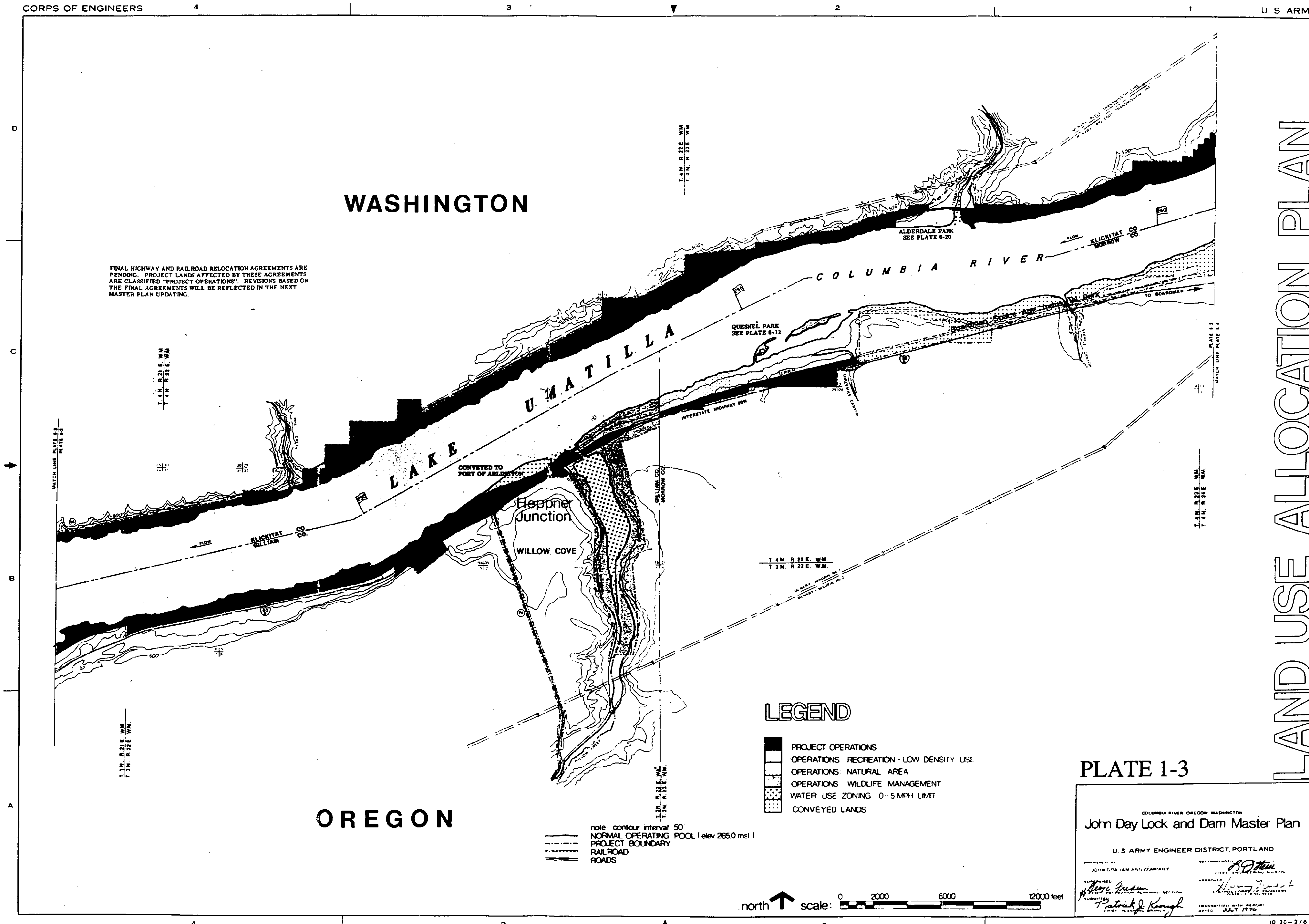
SUPERVISED for CHIEF RECREATION PLANNING SECTION

APPROVED COLONEL CORPS OF ENGINEERS DISTRICT ENGINEER

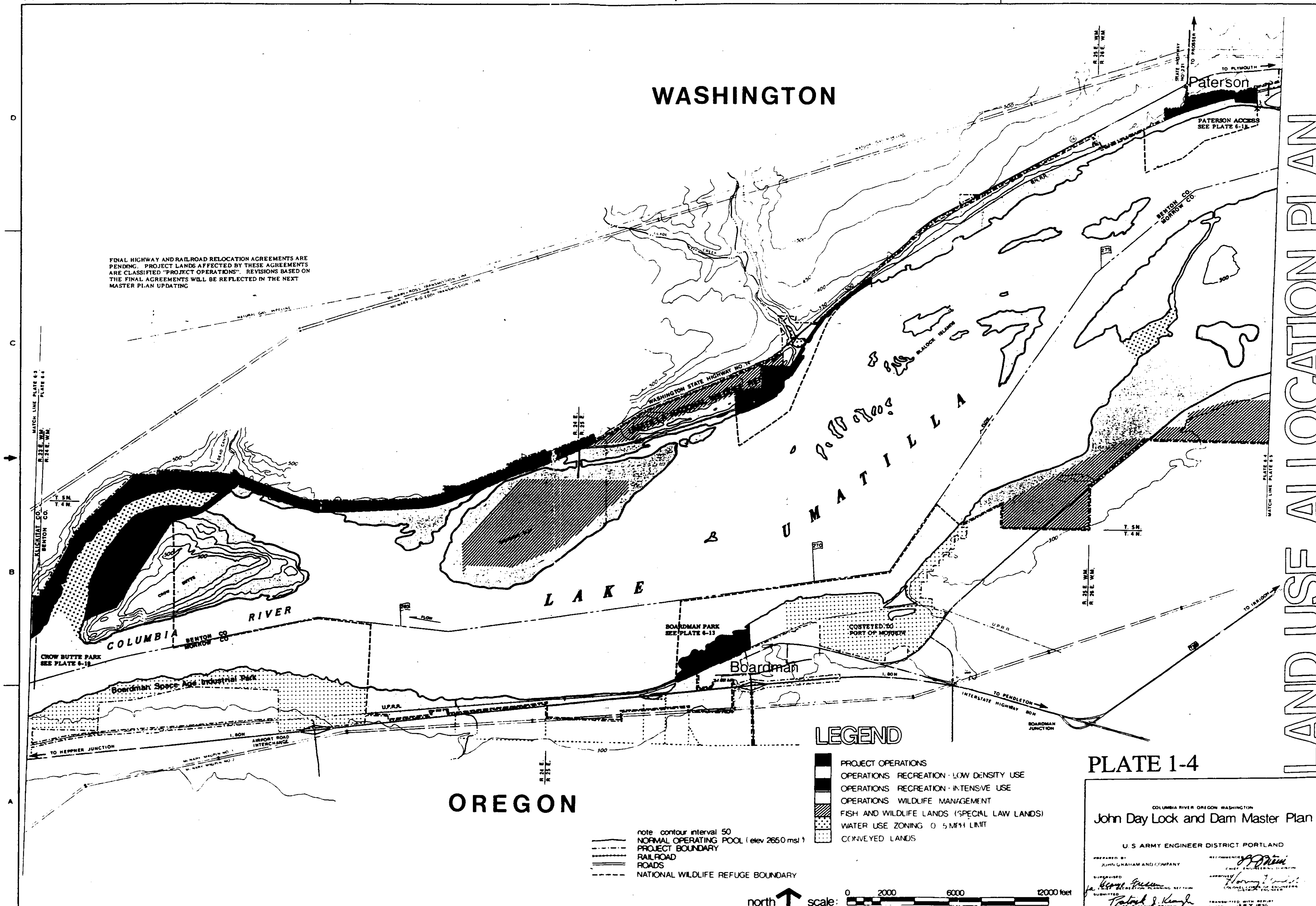
SUBMITTED Patrick J. Keough CHIEF PLANNING BRANCH

TRANSMITTED WITH REPORT DATED JULY 1976

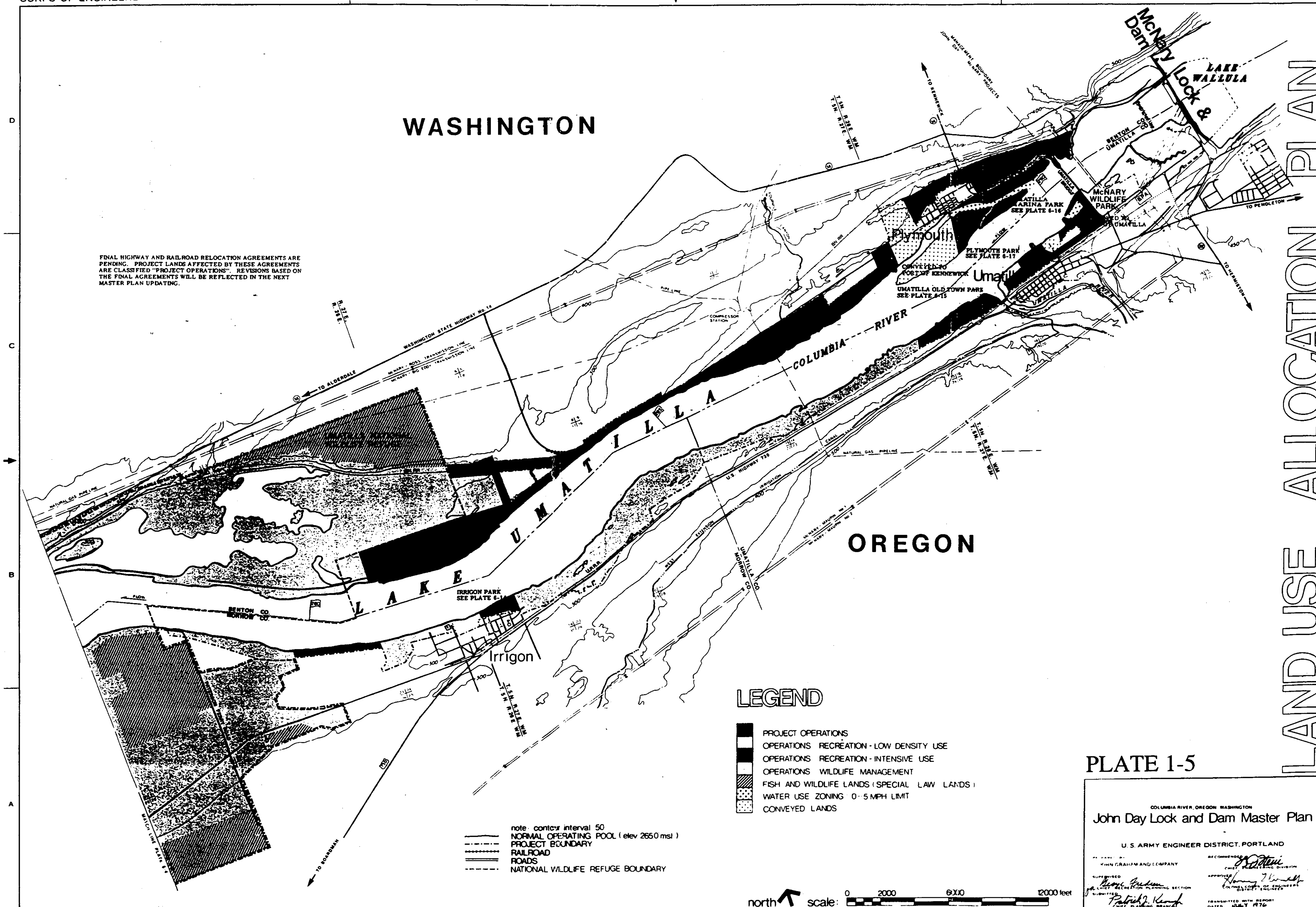
JD 20-2/5



CORPS OF ENGINEERS
U. S. ARMY
WASHINGTON
OREGON
FINAL HIGHWAY AND RAILROAD RELOCATION AGREEMENTS ARE PENDING. PROJECT LANDS AFFECTED BY THESE AGREEMENTS ARE CLASSIFIED "PROJECT OPERATIONS". REVISIONS BASED ON THE FINAL AGREEMENTS WILL BE REFLECTED IN THE NEXT MASTER PLAN UPDATING.
LAKE UMATILLA
COLUMBIA RIVER
ALDERDALE PARK
SEE PLATE 6-20
QUESNEL PARK
SEE PLATE 6-12
CONVEYED TO PORT OF ARLINGTON
Heppner Junction
WILLOW COVE
KLICKITAT CO.
GILLIAM CO.
MORROW CO.
INTERSTATE HIGHWAY 80N
TO BOARDMAN
MATCH LINE PLATE 6-2
T.4N. R.22E. W.M.
T.3N. R.22E. W.M.
LEGEND
PROJECT OPERATIONS
OPERATIONS: RECREATION - LOW DENSITY USE
OPERATIONS: NATURAL AREA
OPERATIONS: WILDLIFE MANAGEMENT
WATER USE ZONING 0 5 MPH LIMIT
CONVEYED LANDS
note: contour interval 50
NORMAL OPERATING POOL (elev. 265.0 msl)
PROJECT BOUNDARY
RAILROAD
ROADS
north
scale: 0 2000 6000 12000 feet
PLATE 1-3
LAND USE ALLOCATION PLAN
COLUMBIA RIVER OREGON WASHINGTON
John Day Lock and Dam Master Plan
U. S. ARMY ENGINEER DISTRICT, PORTLAND
JOHN GRAHAM AND COMPANY
JULY 1976
JD 20-2/6


LAND USE ALLOCATION PLAN
WASHINGTON
OREGON
Paterson
PATERSON ACCESS SEE PLATE 6-18
FINAL HIGHWAY AND RAILROAD RELOCATION AGREEMENTS ARE PENDING. PROJECT LANDS AFFECTED BY THESE AGREEMENTS ARE CLASSIFIED "PROJECT OPERATIONS". REVISIONS BASED ON THE FINAL AGREEMENTS WILL BE REFLECTED IN THE NEXT MASTER PLAN UPDATING
WASHINGTON STATE HIGHWAY NO 14
BLALOCK ISLANDS
LAKE UMATILLA
COLUMBIA RIVER
BENTON CO.
MORROW CO.
KLICKITAT CO.
CROW BUTTE PARK SEE PLATE 6-19
BOARDMAN PARK SEE PLATE 6-13
CONVEYED TO PORT OF MORROW
Boardman
Boardman Space Age Industrial Park
TO HEPPNER JUNCTION
AIRPORT ROAD INTERCHANGE
TO PENDLETON
INTERSTATE HIGHWAY 80N
BOARDMAN JUNCTION
TO IRRIGON
TO PLYMOUTH
U.P.R.R.
LEGEND
PROJECT OPERATIONS
OPERATIONS RECREATION - LOW DENSITY USE
OPERATIONS RECREATION - INTENSIVE USE
OPERATIONS WILDLIFE MANAGEMENT
FISH AND WILDLIFE LANDS (SPECIAL LAW LANDS)
WATER USE ZONING 0 5 MPH LIMIT
CONVEYED LANDS
note contour interval 50
NORMAL OPERATING POOL (elev 265.0 msl)
PROJECT BOUNDARY
RAILROAD
ROADS
NATIONAL WILDLIFE REFUGE BOUNDARY
north
scale: 0 2000 6000 12000 feet
PLATE 1-4
COLUMBIA RIVER OREGON WASHINGTON
John Day Lock and Dam Master Plan
U S ARMY ENGINEER DISTRICT PORTLAND
JULY 1976

CORPS OF ENGINEERS U. S. ARMY



JD 20—2/8